EFFECTS OF ENERGY DENSITY AND PACKAGING FORMAT ON PORTION SIZE ESTIMATION

A thesis submitted by

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ABSTRACT

Background. Consumption of large portion sizes in particular of high energy dense foods has been associated with increased energy intakes and the potential to induce obesity. Estimating how much is adequate to consume at one occasion is however difficult, especially for highly energetic foods, foods sold in large packages and when meals contain a number of items (e.g. restaurant meals and on-the-go "meal deals").

Aims. This study aimed at exploring the role of food energy density (kcal/g) and presentation format (single unit vs. multi-unit) on food portion size estimation in young adults. We also explored the relationship between estimated fat/calorie content and actual fat/calorie content of the test foods; and compared two different methods of portion size estimation to find out which method was associated with less estimation error in multi-item foods.

Design and procedures.

Thirty-two lean, non-restricted subjects (15 males, 17 females) rated the portion sizes of 33 foods under standardised appetite conditions in the laboratory. Foods varied according to energy density (ED); presentation format (single unit food vs. multi-item meals); texture and meal label (i.e. "to be consumed as a snack" or "as a meal"). Outcome measures included liking and familiarity ratings; estimated number of portions, from which %error in estimation versus reference amounts was calculated; estimated fat and calorie content; and comparison to usual portion.

Results. Portion size estimation was significantly different from the Food Standards Agency (FSA) portion size reference amounts for most food/drink items ($p<0.05$). Accuracy in estimation was not influenced by either energy density or presentation, as errors in estimation occurred regardless of energy density, food type and food unit.

Energy density had a significant effect on the percentage error in estimation against FSA standards in both males ($p=0.011$) and females (0.016). Labelling food by their food type (meal, snack, beverage) had a significant effect on percentage error of portion size estimation ($p=0.047$), with a great affect in females ($p=0.036$) than in males ($p=0.088$). Displaying foods by food unit (single, multi-item) had no affect on percentage error. Subjects were able to accurately estimate calorie content when compared against energy density ($r=0.442$, $p=0.010$), total energy load ($r=0.766$, $p=0.000$) and energy density category ($r=0.434$, $p=0.000$). Fat estimation was also accurately estimated when compared against fat density ($r=0.633$, $p=0.000$), total fat content ($r=0.866$, $p=0.000$) and reference fat categories ($r=0.454$, $p=0.000$).

Conclusion. Labelling foods dependent on their food type affects percentage error of portion size estimation, with labelling having a greater affect on females than males. Displaying

foods as a single unit or multi-item food does not affect percentage error of estimation. Subjects were able to accurately estimate fat/calorie content against actual fat/calorie content in the foods displayed.

I hereby declare that work contained herewith is original and is entirely my own work. It has not been previously submitted in support of a Degree, qualification or other course.

Signature .....

Date .....

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BMI	Body mass index
cm	Centimetres
ED	Energy density
FSA	Food Standards Agency
g	Grams
HED	High energy dense or high energy density (>4.0 kcal/g or ml)
kcal	Kilocalories
kJ	Kilojoules
KS	Kolmogorov-Smirnov
LED	Low energy dense or low energy density (0.6 – 1.4 kcal/g or ml)
MED	Medium energy dense or medium energy density (1.5 – 3.9 kcal/g or ml)
ml	Millilitres
mm	Millimetres
PIS	Participant information sheet
SEM	Standard error of the mean
SD	Standard deviation
TFEQ	Three-factor eating questionnaire
VAS	Visual analogue scale
VLED	Very low energy dense or very low energy density (<0.6 kcal/g or ml)

Chapter 1. INTRODUCTION.

1.1. Trends in overweight and obesity in the UK and worldwide

Obesity levels are on the rise, with 22% of females and 24% of males in England being obese (The Health and Social Care Information Centre, 2010). In 2008, under 300 million women and over 200 million men were obese worldwide with a joint projection of 700 million by 2015 (World Health Organisation, 2011). Should obesity in England continue to increase at this rate, 50% of females and 60% of males will be obese by 2050 (Foresight, 2007).

1.2. Background

A portion has been defined as an appropriate amount of food or drink to consume on one eating or drinking occasion (Schwartz & Byrd-Bredbenner, 2006a). What influences what we perceive as a portion and therefore consume has been the focus of research and includes food and drink characteristics such as food type (snacks, beverages, multi-item meals) (Almiron-Roig, Chen & Drewnowski, 2003; Reviewed in Rolls, 2003), physical form (solid, liquid, amorphous, defined shape) (Weber et al, 1999) energy density (kJ/g) (Burger, Kern & Coleman, 2007), fat density (Bell & Rolls, 2001) and other macro-nutrients. There have also been physiological, behavioural and cognitive explanations as to how one perceives a portion. Physiological factors include visual and olfactory cues, sensations of hunger, fullness, thirst (Kral, 2006) and palatability (Yeoman, Blundell & Leshem, 2004). Whereas, unit bias (a sense that a single entity is the appropriate amount to consume)(Geier, Rozin & Doros, 2006), expected satiety (expected benefits after consumption) (Brunstrom & Shakeshaft, 2009) and habitual portion size (Kral, 2006) offer behavioural and cognitive explanations. Furthermore, environmental factors such as normal consumption norms

(Wansink, Kent & Hoch, 1998), packaging (Rolls, Roe, Kral, Meengs & Wall, 2004a) and container size (Marchiori, Corneille & Klein, 2012) all contribute to our perception of a portion.

Consumption of large portion sizes has been associated with positive energy balance and in the long-term, obesity. Therefore investigating what effects some of the above factors have on portion size estimation, could help influence the direction of future research in this field and could help in the development and implimentation of adult weight management strategies. Past research has considered to some extent the effect of energy density (ED) on portion size, for example the results from a recent study in our group (Brogden & Almiron-Roig, 2011) indicated that high energy density foods and caloric drinks lead to greater inaccuracies of portion size estimation compared to foods of lower energy densities. However factors such as meal type and perceived fat and calorie content was not not investigated in relation to energy density and only a limited range of food/drink items were included. Therefore the degree of inaccuracy to which the portion sizes of high- and low-energy density foods are estimated has not yet been fully understood nor quantified.

1.3. The effects of energy density on portion size estimation and energy intake

Evidence has shown that the consumption of high energy density foods and in particular high sugar and/or high fat foods, may be associated with positive energy balance and as a result, weight gain (Bell, Castellanos, Pelkman, Thorwart & Rolls,1998; Rolls et al., 1999). Consumption of large portions of these high energy density foods in particular has been associated with increased energy intakes and the potential to induce obesity (**Table 1**).

Table 1. Studies on the effects of different portion sizes and energy densities have on energy intake in adults

Authors	Participants	Setting, study length and food type	Manipulation of portion size (PS) and energy density (ED)	Effect on energy intake (EI)
Rolls, Morris & Roe (2002)	51 males and females	Laboratory, 1 day/wk for 4 wks, lunch	Different PS of macaroni cheese served (500, 625, 750, 1000 g)	PS increase of macaroni cheese increased mean energy intake (2284, 2552, 2728, 2962 kJ)
Kral, Roe & Rolls (2004)	39 females	Laboratory, 1 day/wk for 6 wks, lunch and dinner	Different PS of pasta (500, 700, 900 g) and ED (5.23, 7.23 kJ/g) Standard meal followed	Large PS of high ED led to a greater intake (925 kJ) than small PS of low ED. PS & ED increase energy intake independently
Rolls et al., (2004a)	60 males and females	Laboratory, 1 day/wk for 5 wks, snack and dinner	Different PS of potato chips (28, 42, 85, 128, 170 g)	PS increase of snacks increased mean intake (577, 820, 1243, 1502, 1577 kJ)
Rolls, Roe, Meengs & Wall (2004b)	75 males and females	Laboratory, 1 day/wk for 4 wks, lunch	Different PS of sandwich baguette (6, 8, 10, 12 in)	PS increase of sandwich increased mean intake (2406, 2941, 3226, 3489 kJ)
Rolls, Roe & Meengs (2006)	32 males and females	Laboratory, 2 day/wk for 3 wks, all meals/snacks	Different PS of foods and snacks (100, 150, 200 %)	PS increase of foods and snacks increased mean 2 day energy intake (21644, 25191, 27363 kJ)

It has been suggested that the long-term exposure of large portions in particular of high energy density meals may have led Westernised societies to conceive a distorted concept of a "normal" portion (Rolls, Roe & Meengs, 2007; Schwartz & Byrd-Bredbenner, 2006a). A study by Kral et al (2004) looked into the combined effects of energy density and portion

size on energy intakes and found that both energy density and portion size act independently on an individuals energy intake. In this study six lunches were served over 6 weeks, each adjusted by either energy density (5.23 kJ/g or 7.32 kJ/g) or portion size (500 g, 700 g or 900 g) each week. Subjects consumed 56% more of the largest high energy dense portion than the smallest low energy dense portion. There are however limitations to this study, with the recruitment of only female participants and the manipulation of only one of the three meals served each day.

The exact mechanisms by which we are driven towards the consumption of larger portions than what we would normally consume at one sitting are not completely understood. Estimating how much is adequate to consume at one occasion is difficult, especially for highly energetic foods, foods sold in large packages and when meals contain a number of items (e.g. restaurant meals and on-the-go "meal deals"), In addition to this large portion sizes (Harnack, Steffen, Arnett, Gao & Luepker, 2004) and amorphous foods (Slawson & Eck, 1997) also present challenges when estimating portion sizes.

The aforementioned study (Brogden & Almiron-Roig, 2011) showed that the portion size of certain high energy density foods including chocolate bars, muffins and crisps, but also medium and low energy dense foods such as hot chocolate, ice-cream and banana, are all inaccurately estimated in male subjects when exposed to them on repeated occasions. This study recruited only male participants and employed only 8 foods in total which limited the degree to which the association between ED and portion size estimation could be studied and results generalised to a wider population. The effects of gender on estimation of portion sizes of high energy foods is controversial. Women have been reported to estimate portions as smaller, compared to men, with no gender differences being observed in lower energy foods (Burger et al., 2007). This has been associated with women being better than men in adjusting portions of foods that may lead to weight gain. Alternately, Rolls et al., (2006) found that increasing portion sizes over 2 days increased energy intake significantly. In

relation to gender, when the portion of foods were doubled, men and women both consumed 26% more energy on average, resulting in an increase of 813 kcal and 530 kcal, respectively.

BMI is an important factor to consider when researching portion size estimations, however, results to-date have been somewhat inconsistent. Burger et al., (2007) found strong links between BMI and the selection of large portion sizes, in young adults, suggesting that those with a higher BMI tend to view larger portions as their their "standard" portion, therefore consuming a greater amount of high energy dense foods. Conversely, Brunstrom, Rogers, Pothos, Calitri & Tapper (2008) failed to find evidence to support a postive relationship between BMI and portion size in all but one test food. Interestingly, a negative relationship was shown for portion sizes of rice, whereby, higher BMI's were associated with smaller portion sizes.

Overall, the evidence shows that different foods covering a range of energy densities are poorly estimated and that differences in estimations between males and females may occur.

1.4. The "unit bias" phenomenon

In relation to food estimation, psychological research also indicates that "unit bias" (also known as "default standard unit bias") happens with foods. Unit bias is defined by Geier et al., (2006) as "a sense that a single entity (within a reasonable range of sizes) is the appropriate amount to engage, consume, or consider". The authors argue that this "appropriate amount" is determined by what is culturally accepted as a standard unit, therefore the portion served as a meal whether at home or in a restaurant would be seen as one unit. This coupled with the culture of "clean the plate" (Krassner, Brownell & Stunkard,

1979) would lead people to consume the portion/unit served, meaning that all food would be consumed regardless of the portion size, within a reasonable range of sizes offered. While this 'plate cleaning' effect may contribute towards the consumption of entire units, it does not completely explain this response to portion size as Rolls et al.,(2004b) found that food intake increased in both participants who reported to "clean the plate" and those who didn't. This effect has also been found to be more common in men than women (Fay et al., 2011).

Another bias that Geier & Rozin (2009) refer to is the "univariate bias" or judgements regarding a food area or volume being dominated by a single dimension, e.g. height over width (Krider, Raghubir & Krishna, 2001). Also as absolute size of food increases, sensitivity to size is reduced (Chandon & Wansink, 2007). When looking into whether these biases played a role in the estimated caloric content of meals, Geier & Rozin (2009) found that both played an influence on subjects estimations. Univariate bias was demonstrated when subjects ignored the thickness of foods and based estimated calorie content on surface area e.g. in meat loaf. Default standard unit bias also occurred categorically, with calories in larger than normal portions being underestimated and calories in smaller than normal portions being overestimated, this has previously been observed by Faggiano et al (1992) who explained this phenomenon, terming it the "flat slope syndrome". Methodologically, despite Geier & Rozin's (2009) large sample size in this study (n = 388), the fact that there is no standardisation of appetite conditions and the absence of a screening process (Blake, Guthrie & Smicklas-Wright, 1989) brings a number of limitations to their conclusions. Brogden & Almiron-Roig (2011) looked into the effect appetite status has on estimation and found that portion sizes were estimated as larger when subjects were full, compared to when they were hungry. This highlights the need for appetite standardisation in portion size studies.

When looking into the relationship between food composition and portion sizes a study by Rolls et al., (2007) found that most participants successfully identified a significant increase in portion size between the larger and baseline portions of entrees and desserts.

However these participants were unable to rate any differences in fat or calorie content between the larger and baseline portions. As noted by Wansink and Ittersum (2007), we are less accurate at estimating our calorie intake as portion sizes increase. This is particularly interesting when looking at multi-item meals as it has been seen that people assume that adding a healthy food such as vegetables to an unhealthy meal, decreases its calorie content (Chernev & Gal, 2010), a misperception that has been coined the "negative calorie illusion" (Chernev, 2010).

1.5. The effects of unit size and food composition (macronutrient content) on portion size estimation and energy intake

Research is now looking into how the presentation format, food composition and our past eating experiences may contribute towards portion size estimation. More specifically, recent studies are looking into the effect multi-item foods have on an individuals perception of portion size. Foods that are served as units tend to be consumed in whole (Rolls, 2003). On the other hand, portion sizes of multi-item foods are difficult to predict. Multi-item foods, refers to the inclusion of more than one unit of food. Keenan, Ferriday & Brunstrom (n.d.) when presenting participants with images of buffet foods (varying in number of food items displayed), they found that perceived volume plays a key role in portion size selection when multi-item foods are available. Rolls et al. (2007) showed that the consumption of fruit was increased when served within a large portion of a multi-item meal but not when served as a snack, and that contrary to previous studies (Rolls et al., 2006) the consumption of

vegetables was not significantly increased when served within meals or individually as snacks. Despite multi-item foods leading to higher consumptions, this research indicates that vegetables do not follow this trend. In support of this Rolls et al (2007) when further investigating portions of multi-item foods suggest that a stepped increase in portion sizes and therefore energy density of all foods except fruit (as a snack) and vegetables did not lead to compensation for higher intakes when served over a period of 11 days.

Studies that investigated perceived portion size of single foods have produced opposed results in comparison to studies focusing on perceived portion size of multi-item foods (Kral et al., 2004; Rolls et al., 2004b). In a study by Kral (2006), participants were asked to rate the portion size of single food items in comparison with their usual portion, and found that when the portion size increased the ratings of perceived portion size by the subjects also increased significantly. Rolls et al. (2004b) also showed a significant increase in subjects ratings of portion size compared to their usual portion, when the portion size of sandwiches was incrementally increased up to double the initial length of the sandwich across conditions. In conjunction with this, subjects still consumed more energy when offered the 12-inch sandwich, with females consuming 12% and males 23% more energy then the 8-inch sandwich.This indicates that although participants were aware of an increase in portion size they still consumed more.

Another study investigating consumption of crisps as a snack found that more crisps were consumed when subjects were presented with a larger pack size. Despite these subjects feeling fuller following consumption of the larger portions, they did not alter their intake at dinner that night to compensate for the increased calorie intake (Rolls et al., 2004a). This further confirms the notion that you can be aware of portion differences and still overeat.

When the role that fat and calories on portion size estimation was analysed, one study found that participants were unable to report changes in the fat and calorie content of foods after their portion sizes were increased by 50%, with no reported differences between sex

group (Rolls et al., 2007). However, another study found that women estimated portions of high fat foods as smaller in comparison to males, with no observed difference in estimation between sex group for low fat foods. Interestingly, this study also reports that participants were more likely to overestimate the portion sizes of foods with a high carbohydrate content that those with a high fat content (Burger et al., 2007). However one must be cautious when comparing these results to other studies as the method of classification of foods based on carbohydates and fats differ somewhat. With both studies being based within university laboratory settings, it is unlikely that participant characteristics will be comparable to that of the general population, as a laboratory setting enables the isolation from and control of many other factors that effect the estimation of portion size, but imposes an artificial context (McBurney & White, 2009).

1.6. Methods of estimating portion sizes

When reviewing the literature on portion size studies, one must be aware of the different methods adopted between countries. For instance, there are limitations when comparing studies from the U.S and U.K due to cultural differences, including eating behaviours and food availability. In addition to this there are also different guidelines on what constiutates a 'normal portion'. U.S portion sizes have increased across a range of food categories when eaten both in and out of the home environment (Nielsen & Popkin, 2003). This may lead to a greater level of distortion of perception of a portion size. Despite a limited number of U.K studies on changes in portion sizes, a review by Church (2008) has indicated that U.K portion sizes of standard products have remained reasonably constant over the last 15-20 years. Clearly, the U.S's dominance in the fast food industry (e.g. Burger King and McDonalds) will impact on this due to an increase in portion sizes in fast food outlets (Wrieden, Gregor & Barton, 2008).

As outlined, the estimation of portion size is dependent on an individual's perception, which is likely to be influenced in some part by energy density, food composition, presentation format and past eating experiences, thus making the estimation of portion sizes very subjective in nature. It is therefore necessary to recruit another means of establishing to what basis their "usual portion" compares to this. In a previously mentioned study Rolls et al., (2007) where participants after taking one bite of the foods served were asked how the size of the serving compared with their usual portion on a scale anchored by "a lot smaller" and "a lot larger", they found that increased portion sizes of multi-item foods did not lead to compensation for higher intakes. The authors suggest that the use of particular portion size estimation questions compared to "usual" portions may not have been sensitive enough to detect these effects in multi-item meals (Kral, 2006).

Other methodological issues have arisen when investigating the estimation of portion sizes. For example, Hernandez (2006) recognised the cognitive burden associated with participants using rulers or counting grids to gauge the size of foods presented, he therefore incorporated the use of standardised plates to display the foods. In addition to this he adopted a methodology using computer-based portion size estimation. Two food images (with standardised lighting and camera positions) varying by size or form for each food or container were displayed in relation to screen size, whilst life size poster images were presented in one of the test sites. Results showed that computer displayed photographs perform just as well as life-size photographs whilst having the benefit of being more accessible.

These studies, both in terms of the sensitivity of the questions used and the way foods are presented compared to measuring aids, lead us to question what an acceptable and realistic level of accuracy is when estimating portion sizes.

In summary this review of the literature has indicated that high energy density foods tend to be chosen in significantly larger portions than low energy density foods (Burger et al., 2007) and their portion sizes are poorly estimated (Brogden & Almiron-Roig, 2011; Rolls et al., 2007; Yuhas, Bolland and Bolland, 1989). Foods served in single units tend to be consumed in whole and portion sizes of multi-item foods are often difficult to predict (Rolls, 2003).The role fat and calories play in portion size estimation (Rolls et al., 2007; Burger et al., 2007) and what is the most sensitive method to meaure portion estimation across food types and food unit sizes remains unclear.

The present study will include the estimation of portion sizes in composite meals made of multi-item foods (referred hereafter as multi-item meals) together with individual foods and beverages of a wide range of energy densities in order to analyse whether portion estimation varies across food type, if the portion sizes of high energy dense multi-item meals are poorly estimated in comparison to low energy dense multi-item meals and if the calorie and/or fat contents influence estimations. To increase the sensitivity of our study we will use a previously validated questionnaire to test the subjects' abilities in estimating the portion sizes of both single item and multi-item focusing on the subjects perception at that moment in time (Brogden & Almiron-Roig, 2011). In additional we will also ask the subjects to relate the portion displayed to their usual portion, using a previously validated VAS. This will allow us to compare two current methods of estimating portion sizes and how sensitive they are to portion size across both single and multi-item foods. Finally, Wansink (2010) found participants used food and environmental cues are used to determine whether they were eating a snack or a meal. Therefore, we will label each food/drink item as "a meal", "a snack" or "a beverage" to reduce the impact this variable may have on portion size estimation between participants.

1.7. Aims, objectives and hypotheses

This study aims at quantifying the association between energy density (ED) and portion size estimation in adults, with a focus on how food type (unit and multi-items) and food composition (fat and calories) and can affect this relationship.

The study objectives are:

(a) Explore the association between energy density and portion size estimation in adults, using a broad range of food items

(b) Explore portion size estimation in unit vs. multi-item foods across:
    i) Energy density, fat and energy levels
    ii) Food types (snack vs. non-snack meals and beverages)

(c) Compare two current methods of estimating portion sizes ("usual portion" vs. displayed portion) especially in regards to multi-item foods

The study hypotheses are:

Primary hypothesis:

Portion size of high energy density foods will be estimated less accurately than portion size for foods with a lower energy density. There will be a positive correlation between the foods energy density and decreased accuracy of estimation measured as percentage error in portion estimates when compared to reference amounts.

Secondary hypothesis:

(i) Portion size of single unit items will be estimated more accurately than portion size of multi-item foods, irrespective of energy density levels in both males and females.

(ii) Portion sizes of multi-item foods of a high ED will be estimated less accurately than portion sizes of multi-item foods of a medium or low ED in both males and females.

(iii) For single unit and multi-item foods of high and medium ED the fat and energy content of large portions will be estimated less accurately than that of smaller portion sizes in both males and females.

(iv) Subjects will have a better ability to estimate what they constitute as normal portions of different foods in multi-item meals by answering the displayed portion question than the “usual portion” VAS tool.

Chapter 2. METHODS.

2.1. Study design.

This study employed a within-subjects, repeated measures design with each participant returning for three separate test sessions, spaced apart by a minimum of 7 days. Each subject estimated the portion size; fat content; calorie content and comparison to their usual portion of 11 different foods and/or drinks each visit. Giving a total over the three test sessions of 33 foods and drinks, which were of various different energy densities (very-low, low, medium and high). These foods/drinks included 23 single items like snacks and caloric beverages, but also 10 multi-item foods.

The independent variables were hunger, fullness, thirst and energy density. Hunger, fullness and thirst were measured using Visual Analogue Scales (VAS) based on Hill and Blundell (1982) (**Appendix 1a**). Energy density was classified based on the system by Rolls and Barnett (2000). The dependent variables were estimated portion size, fat content, calorie content and usual portion comparison. Portion size was measured using a previously piloted questionnaire (Brogden & Almiron-Roig, 2011) (**Appendix 1b**). Fat, calorie and usual portion comparison were measured using a validated VAS (Rolls et al., 2007; Kral, 2006) (**Appendix 1b**). Quantitative data were collected for 12 weeks, between December 2010 and March 2011.

2.2. Population, sample, and sample size estimation.

Sample size was estimated following consultation with a statistician (Colin Sinclair, University of Chester), as based on a previous study (Blake et al., 1989) and the use of a power calculation. Given two groups (male and female) an inclusion of 26 subjects was

necessary to detect differences in portion size estimation (alpha 0.05; 85% power). With the inclusion of a drop-out rate of 25% (Almiron-Roig & Drewnowski, 2003), 32.5 subjects were necessary to maintain 85% power. This power was achieved as 15 males and 17 females took part in the study.

Participants were recruited by means of advertisements (**Appendix 2a**) in paper and email form, social networking site advertisement and flyers posted on the University of Chester campus and the surrounding area. Based on methods from Brogden & Almiron-Roig (2011), eligibility criteria were set as: being a normal weight (BMI between 18.5-27.9[1]); being aged between 18-45 years; being non-dieting; consuming breakfast regularly and being non-smokers. Exclusion criteria were set as: having any medical condition affecting their diet, appetite or satiety; having any food allergies, intolerances or restrictions; having a history of weight cycling over the last ten years; taking prescription medications/supplements which may have affected their appetite; being an athlete in training or being involved in intense physical activity (>10 hours per week); having prior knowledge of the study or relevant qualifications in nutrition; disliking or being unfamiliar with more than 50% of the food/drink items.

Individuals wishing to participant in the study received an initial information letter (**Appendix 2b**), on agreement to these study requirements verbal consent was gained to undertake the telephone interview. Individuals were then further checked for eligibility via the telephone pre-screening interview (**Appendix 2c**). All potential individuals at this stage were invited to the laboratory for confirmation of their weight, height and BMI; and to determine their liking and familiarity ratings for the test foods and drinks (using a 100mm VAS as previously reported (Brogden & Almiron-Roig, 2011) (**Appendix 2d**). Food/drink items with liking or familiarity scores ≤49 were considered as disliked or unfamiliar based on Mobini, Elliman & Yeomans (2005) and Raudenbush and Frank (1999).

[1] The 'normal weight' cut off point was raised from 24.9 to 27.9 to prevent exclusion of subjects with considerable muscle mass.

Participants eating habits and dietary restraint (cognitive restraint, disinhibition and hunger) were then assessed during the laboratory screening, using the Three Factor Eating Questionnaire (TFEQ) from Stunkard and Messick (1985) (**Appendix 2e**). Study inclusion was subject to participants scoring a disinhibition score of <8 on the disinhibition scale, or those with a score of <10 on the cognitive restraint scale and <7 on the hunger scale.

On confirmation of eligibility participants received a Participant Information Sheet (PIS) (**Appendix 3a**), provided written informed consent prior to any laboratory procedures taking place (**Appendix 3b**) and were given at least 48 hours to decide their wish to participate in the study.

In order to standardise baseline appetite levels based on methods from Tsuchiya, Almiron-Roig, Lluch, Guyonnet & Drewnowski (2006), participants were asked to refrain from alcohol consumption; keep their activity levels and evening meals as similar as possible the day prior to all three tests; consume their 'usual' breakfast for themselves at 8:30 am on the morning of the test day (Bell et al., 1998); not consume any food between 8:00 pm the prior night up to 8:30 am when they consumed their usual breakfast and consume the snack provided (Nestle KitKat Chunky, 48g) at 10:30 am on each test day. To ensure compliance this information was monitored using a simplified food diary questionnaire (Brogden & Almiron-Roig, 2011) (**Appendix 3c**).

Ethical approval for the study was obtained from the Research Ethics Committee, Faculty of Applied and Health Sciences, University of Chester (**Appendix 3d**). All 32 participants completed the study and received £20 reimbursement for their participation, in the form of a supermarket voucher.

2.3. Materials and Procedures.

2.3.1. Visual analogue scale (VAS) ratings.

Participant hunger, fullness and thirst levels were recorded using 100mm visual analogue scale (VAS) establishing baseline appetite levels prior to each test session. The use of VAS scales in appetite research is based on widely used, validated research methodology (Hill and Blundell, 1982; Flint, Raben, Blundell & Astrup, 2000) and have been previously used in our laboratory to assess feelings in hunger, fullness and thirst (Brogden & Almiron-Roig, 2011). The VAS questions were presented as a booklet with one question per page including: "How hungry do you feel?" with the scale ranging from "Not hungry at all" to "Extremely hungry"; "How full do you feel?" ranging from "Not full at all" to "Extremely full" and "How thirsty do you feel?" from "Not thirsty at all" to "Extremely thirsty". Three distraction questions were used as in previous studies to remove any experimental bias (Burger et al., 2007; Almiron-Roig and Drewnowski, 2003; Brogden & Almiron-Roig, 2011). These included "How alert do you feel?", "How tired to you feel?" and "How sleepy do you feel?" each anchored by "not at all" to "extremely". The data from these three distracting questions were not analysed.

2.3.2. Test foods and drinks.

Information on all test foods and drinks used in this study including brands, type of food, food unit, energy load, energy density category and portion sizes displayed by manufacture and Food Standards Agency (FSA) reference amounts are detailed in **Appendix 4a**; portion size and energy load for individual food items in multi-item foods in **Appendix 4b**; and FSA portion sizes for individual food items in multi-item foods in **Appendix 4c**. The energy density of the food/drink items were classified based on the system by Rolls & Barnett (2000): VLED = very low energy density (<0.6 kcal/g or ml); LED = low energy density (0.6 to 1.4 kcal/g or ml); MED = medium energy density (1.5 to 3.9 kcal/g or ml); HED = high energy density (≥ 4.0 kcal/g or ml). The foods included single items like snacks and caloric beverages, but also multi-food items like pizza with dip.

Food unit category was defined by the number of units of the food item/s displayed, one unit was classed as a single item (n = 21), while more than 1 unit was classified as a multi-item (n = 12). For food type, all drinks were classed as beverages (n = 4) whereas foods were either classed as a snack (n = 16) or a meal (n = 13) dependant on what these foods would be perceieved as if eaten at the time of the test. The food/drink items displayed represented the food/drink items that were available on campus and that would typically be consumed by students/staff as a snack or as a meal at that moment in time.

The actual reference portion sizes for the food/drink items were calculated based on the set portion guidance provided by the Food Standards Agency (FSA) (Crawley, 2002). For multi-component foods which were not listed in the FSA portion size reference book (Crawley, 2002), the reference portion size was calculated from the sum of the portion size of each food item in the meal (by FSA standards) divided by the number of items in the meal.

Images of how each food/drink was presented can be seen in **Appendix 4d**. Information on brands, weights/volumes and nutritional label or nutritional claims were covered to diminish product bias. The test foods/drinks were displayed with one of following prompts, "...as a drink", "...as a snack" or "...as a meal" e.g. "orange juice as a drink" (**Table 2**).

All meals were covered with a transparent plate cover to prevent any food smells influencing the participants responses, unless stated otherwise (**Appendix 4d**).

Due to the amount of space available in the lab a maximum of 11 test booths were employed at each session. Each booth displayed a defined portion of a particular food/drink item. The amounts presented were based on commercial pack, manufacture's guidelines for one portion or container size of each item (Brogden, 2009). The order of presentation of the items displayed over the three days was randomised across test sessions (**Appendix 4e**).

Table 2. Details of the test foods, their prompts and how they were presented.

Prompt	Food/Drink item	Presentation
...as a drink	Fresh orange juice	Presented as sold
	Cola drink	Presented as sold
	Whole mik	Presented as sold
	Hot chocolate	As an empty takeaway container with a heat proof lid as sold by a well known coffee retailer
...as a snack	Pork pies	Presented as sold
	Light vanilla yoghurt	Presented as sold
	Flapjack	Presented as sold
	Chocolate bar	Presented as sold
	Cereal breakfast bar	Presented as sold
	Sausage roll	Presented as sold
	Crisps	Presented as sold
	Cheese and crackers	A slice of cheese on each of the 8 crackers, on a small individual plate (16 cm diameter) covered with cling film
	Fruit salad	Emptied into and displayed in a bowl (16 cm diameter, 4 cm depth) covered with cling film
	Croissant	Presented individually on small plates (16 cm diameter) covered with cling film and frozen between test sessions
	Malt loaf	Presented individually on small plates (16 cm diameter) covered with cling film
	Blueberry muffin	Presented individually on small plates (16 cm diameter) covered with cling film and frozen between test sessions
	Peanuts	Presented in a small glass bowl (10 cm diameter, 5 cm depth) covered with cling film
	Banana	One purchased each week and each weight recorded, the mean weight ± standard deviation (SD) was 140.2 ± 1.8g. As in our previous study (Brogden, 2009) the shape was kept consistent by using a template created around the shape of the banana used in the first test session
	Cottage cheese on crispbreads	Cottage cheese was distributed evenly over two crispbreads and displayed on a small individual plate (16 cm diameter), covered with a transparent plate cover.
	Ice-cream	Presented as the empty tub it was sold in
...as a meal	Peanut butter on toast	Presented as two slices diagonally sliced and displayed on a large individual plate (25 cm diameter)
	Country vegetable soup	Emptied into and displayed in a bowl (14.5 cm diameter, 8 cm depth), covered with cling film
	Chicken salad bowl with a caesar dressing	Presented in a large glass salad bowl (20 cm diameter, 9 cm depth), covered with cling film
	Biscuit cereal with semi-skimmed milk	Presented in a bowl (16 cm diameter, 4 cm depth), with the milk displayed in a tall glass (6 cm diameter, 13 cm depth), both covered with cling film

	Instant chicken flavoured noodles	Cooked, cooled and displayed in a bowl (16 cm diameter, 4 cm depth)
	Beans and cheese on toast	Cooled and displayed on a large dinner plate (25 cm diameter)
	Chicken in black bean sauce with rice	Cooled and displayed on a large dinner plate (25 cm diameter)
	Cottage pie with broccoli and carrots	Cooled and displayed on a large dinner plate (25 cm diameter)
	Macaroni cheese	Emptied into and displayed in a bowl (16 cm diameter, 4 cm depth)
	Chicken sandwich roll meal	The roll was heated, cooled and displayed on a large dinner plate (25 cm diameter) displayed next to a chocolate bar (85g) and can of cola drink (330ml)
	Meat pizza and dip	2 slices and a dip pot displayed on a large dinner plate (25 cm diameter), the pizza was purchased from a well known pizza retailer, the slices of pizza were weighed with a mean weight ± SD of 160 ± 0.4g. The portions were then frozen in-between the test sessions.
	Cheese and ham quiche and coleslaw	Presented on a large dinner plate (25 cm diameter)
	Bacon and cheese panini meal	Cooked, cooled and displayed on a small individual plate (16 cm diameter), covered with cling film and displayed next to crisps (25g) and cranberry juice (200ml)

2.3.3. Estimation of food/drink portion sizes, usual portion, fat and calorie content.

For each test food, participants were asked to answer four questions presented in a question booklet depending on the visual cue presented with each item, for example “as a snack” or “as a meal” (Burger et al., 2007).The question on portion size asked subjects “how many portions of X are in this (container type)” (Brogden & Almiron-Roig, 2011), with participants being asked to record their answer as a full number or as a fraction, for example 1, 0.5 or 1½. The following three questions asked participants to rate their answers on a 100mm VAS scale: the usual portion question asked “how does this serving compare to your usual portion of X food/drink?” anchored by “a lot smaller” to “a lot larger” (Kral, 2006); the fat content question asked “how much fat do you think this portion of X contains?” anchored with “no fat at all” to “extremely high in fat”; and the calorie content questions asked “how many calories do you think this portion of X contains?”, anchored with “no

calories at all" to "extremely high in calories" (Rolls et al., 2007). The order of these four test questions was randomised across subjects (**Appendix 4f**) and each question was on a separate page in the booklet to avoid any reflection on a previous answer when completing the remainder of the questions. For this reason subjects were also asked not to look back at any questions once they had been answered.

2.3.4. Procedures.

Subjects arrived at the laboratory at 12.00 p.m following the consumption of their usual breakfast at 08:30 a.m and the snack provided at 10:30 a.m only, with the exception of non-carbonated water. At 12:10 p.m the subjects attended a 15 minute briefing session, they were given 5 minutes to complete the food and activity diary questionnaire, 5 minutes to complete the VAS questionnaire on hunger, fullness and thirst and 5 minutes to read through the instructions for the portion size question booklet. After reading though this booklet all participants were then verbally reminded that the definition of a portion is "the quantity of food/drink that you would consume on one eating/drinking occasion" (Schwartz and Bred-Bredbenner, 2006a) and to ask themselves before answering the question "would I be able to consume all of that food/drink at this moment in time?" They were then reminded of their ID number, informed of their starting location within the test room and reminded not to look back at their answers after completing them and not to talk during the test. At 12:25 p.m subjects moved to the test room, located their starting booth and started the test. Subjects were given a minute at each booth to answer the four questions, when instructed by the lead researcher they then rotated in a clockwise direction and repeated the process until all 11 booths and corresponding questions in the booklet had been completed.

On completion of the test subjects returned to the laboratory to give the lead researcher their completed portion size question booklet and to receive their free snack on which was a reminder sticker detailing the date and time of the next test session and when the free snack should be consumed. This procedure was repeated at the following two test

days. On completion of the third and final test day, the participants received their supermarket gift voucher of £20 and the option to ask any questions regarding the study.

All the data collected from the subjects were coded for confidentiality, with the papers locked in a filing cabinet and any data inputted was onto a computer which was password protected. All information collected was accessible to the lead researcher and academic supervisor only.

2.4. Data management and data analysis

The significance level for all statistical analyses was set to <0.05 and all tests were carried out using SPSS for Windows, Version 18.0 (SPSS (UK) Ltd.).

Normality tests were performed using the Kolmogorov-Smirnov (KS) test for: hunger, fullness and thirst ratings; familiarity and liking ratings; portion size estimates; usual portion scores; estimated fat and calorie content; portion estimate means for food types and food units, test food presentation sequence, percentage error of portion size estimation, actual energy density and energy density category.

Departure in portion estimates from reference amounts (percentage error in estimation), was calculated as follows:

% error actual values = 100* [(mean estimate – FSA reference)/ FSA reference]

For absolute percentage error of estimates percentage error values <0 were transformed into positive values, whilst positive values were kept the same. This gave a measure of magnitude of under- or overestimation irrespective of the direction of error (above or below the reference amount).

One-way repeated measures ANOVA using the Bonferonni correction was carried out on baseline mean hunger, fullness and thirst ratings, however where Mauchly's sphericity test was violated ($p<0.05$) the Greenhouse-Geisser correction was used to determine the level of significance of the data.

A Mann-Whitney test was used to compare the differences in mean portion estimates between men and women across all foods. Wilcoxon tests were used to explore differences in percentage error of estimation (actual) between food types (snacks vs. non-snack meals and beverages) and food units (single unit foods vs. multi-item foods) for the whole group and by sex group. The effects of energy density category on percentage error of portion estimates was analysed for the whole group and by sex group using the Friedman test.

A Wilcoxon signed rank test was used to analyse the difference between mean portion estimates and the Food Standards Agencies reference amounts. A number of Spearman's correlation tests were performed as part of the fat/calorie analyses including: association between estimated and actual fat/calorie values, association between percentage error of estimation and actual contents of fat/calories and association between percentage error of estimation and estimated fat/calorie content.

To compare the two different methods of portion size estimation a Wilcoxon Signed-Rank test was used to analyse the departure of portion estimates and a one-sample t-test was used to analyse the departure of VAS scores, from their expected normal portion amounts.

Chapter 3. RESULTS.

3.1. Subject sample.

All 32 participants completed the study (15 males and 17 females), there were no drop-outs. The mean BMI (± SD) was 23.9 ± 2.7 kg/m^2 for the whole group and 25.1 ± 2.5 for males; 22.8 ± 2.5kg/m^2 for females. Mean age (± SD) was 25.0 ± 5.9 years for the whole group and 27.4 ± 7.6 for males; 22.7 ± 2.5 years for females. Mean dietary restraint, disinhibition and hunger scores (± SD) were 4.5 ± 2.7, 4.1 ± 1.6 and 5.3 ± 2.0, respectively for the whole group and 3.4 ± 2.9, 4.1 ± 2.1 and 6.0 ± 2.2 for males; 5.4 ± 2.2, 4.1 ± 1.2 and 4.8 ± 1.8 for females.

3.2. Normality tests.

3.2.1. Hunger, fullness and thirst

The Kolmogorov-Smirnov (KS) test for hunger, fullness and thirst confirmed a normal distribution ($p>0.05$) for all three variables on each test week for the whole group and by sex sub-group.

3.2.2. Familiarity and liking ratings

VAS ratings for familiarity across the whole group were non-normally distributed ($p<0.05$) for 32 items, while macaroni and cheese was normally distributed ($p>0.05$).

VAS ratings for liking across the whole groups were non-normally distributed ($p<0.05$) for 23 items, the remaining 10 items were normally distributed ($p>0.05$) and included cola drink, fruit salad, light vanilla yoghurt, chicken salad bowl with a caesar dressing, instant chicken flavoured noodles, crisps, macaroni and cheese, chicken in black

bean sauce with rice, chicken sandwich roll, chocolate bar and a can of cola drink meal and cheese and ham quiche and coleslaw.

3.2.3. Portion size estimates

VAS ratings for portion size estimates were non-normally distributed for all foods/drinks across the whole group ($p<0.05$).

Analysis by sex group confirmed that estimates were non-normally distributed for all foods/drinks in males ($p<0.05$); and all foods/drinks in females ($p<0.05$), except for ice cream and macaroni and cheese, which were normally distributed in females ($p>0.05$).

3.2.4. Mean portion estimate across food types and food unit size

Mean VAS ratings were normally distributed for snacks ($n = 16$, $p>0.05$), but were not normally distributed for non-snack meals and beverages ($n = 17$, $p<0.05$). Analysis by sex group confirmed that estimates for snacks and non-snack meals and beverages were non-normally distributed ($p<0.05$) in both males and females.

Mean VAS ratings were normally distributed for single unit foods/drinks ($n = 21$, $p>0.05$), but were not normally distributed for multi-item foods ($n = 12$, $p<0.05$). Analysis by sex group confirmed that estimates for single unit foods were non-normally distributed ($p<0.05$) for both males and females. Multi-item foods however, were normally distributed ($p>0.05$) in males, but non-normally distributed ($p<0.05$) in females.

3.2.5. Percentage error of portion size estimation

The KS test for percentage error (actual values) of portion size estimation for all foods ($n=33$) compared to the Food Standards Agency (FSA) portion size reference amount revealed a non-normal distribution ($p<0.05$) for the whole group ($n = 32$) and by male and

female sex group. Percentage error (absolute values) also followed a non-normal distribution ($p<0.05$) for the whole group ($n = 32$) and by female sex group, absolute values for the male sex group however followed a normal distribution ($p>0.05$).

3.2.6. Actual energy density and energy density category

The KS test for both energy density (kcal/g) and energy density category (very-low, low, medium and high) both confirmed a non-normal distribution ($p<0.05$).

3.2.7. Estimated fat and calorie content

VAS ratings for estimated fat content across the whole group were normally distributed ($p>0.05$) for 25 items, the remaining 8 items were non-normal ($p<0.05$) and included: cola drink, whole milk, croissant, flapjack, cottage cheese on crispbreads, cottage pie with broccoli and carrots, cheese and ham quiche and coleslaw and bacon and cheese panini, crisps and cranberry juice meal.

Analysis by sex group confirmed that estimates in males were normally distributed ($p>0.05$) for 30 items, the remaining 3 items were non-normal ($p<0.05$) and included: light vanilla yoghurt, beans and cheese on toast and cottage pie with broccoli and carrots. Female estimates were normally distributed ($p>0.05$) for 29 items, the remaining 4 items were non-normal ($p<0.05$) and included cola drink, country vegetable soup, flapjack and meat and barbeque sauce pizza with dip.

VAS ratings for estimated calorie content across the whole group were normally distributed ($p>0.05$) for 27 items, the remaining 6 items were non-normal ($p<0.05$) and included whole milk, instant chicken flavoured noodles, flapjack, cottage pie with broccoli and carrots, country vegetable soup and peanuts.

Analysis by sex group confirmed that male estimates were normally distributed ($p>0.05$) for 26 items, the remaining 7 items were non-normal ($p<0.05$) and included orange juice, hot chocolate, country vegetable soup, croissant, instant chicken flavoured noodles, blueberry muffin and peanuts. Female estimates were normally distributed ($p>0.05$) for 31 items, the remaining 2 items were non-normal ($p<0.05$) and included whole milk and flapjack.

3.2.8. Description of "usual portion" variable and usual portion scores

To analyse the usual portion data I used the mean VAS rating for the whole group (n=32) and by sex group (males = 15, females = 17) for each food item (table 12). The KS test confirmed mean VAS ratings for usual portion were normally distributed ($p = 0.200$) for the whole group and by sex group.

Average usual portion VAS ratings were calculated by food type (snacks (n=16) vs. non-snack meals and beverages (17)) and food unit (single items (21) vs. multi-item meals (12)) for the whole group and by sex group (table 13). VAS ratings for usual portion were normally distributed ($p>0.05$) for both foods types and food units, by the whole group and by sex groups.

VAS ratings of usual portion scores across with whole group were normally distributed ($p>0.05$) for 19 items, the remaining 14 items were non-normal ($p<0.05$) and included pork pies, whole milk, hot chocolate, cereal breakfast bar, orange juice, cola drink, peanut butter on toast, light vanilla yoghurt, banana, croissant, biscuit cereal with semi-skimmed milk, instant chicken flavoured noodles, blueberry muffin, and bacon and cheese panini, crisps and cranberry juice meal.

Analysis by sex group confirmed that estimates in males were normally distributed ($p>0.05$) for 26 items, the remaining 7 items were non-normal ($p<0.05$) and included: pork pies, cola drink, whole milk, biscuit cereal with semi-skimmed milk, instant chicken

flavoured noodles, crisps, and chicken sandwich roll, chocolate bar and can of cola drink meal. Female estimates were normally distributed ($p>0.05$) for 23 items, the remaining 10 were non-normal ($p<0.05$) and included: cola drink, peanut butter on toast, light vanilla yoghurt, croissant, biscuit cereal with semi-skimmed milk, instant chicken flavoured noodles, blueberry muffin, cereal breakfast bar, meat and barbeque sauce pizza with dip and bacon and cheese panini, crisps and cranberry juice meal.

3.2.9. Test food presentation sequence

The KS test for the sequence of test food presentation confirmed a normal distribution ($p>0.05$) for the randomised order in which the foods were presented across the three test sessions.

3.3 Mean VAS for liking and familiarity

As liking and familiarity scores were non-normal the medians and interquartile range's for all food/drink items are shown (**Table 2**).

Table 2. Median and interquartile range (IQR) liking and familiarity scores for the whole group (n = 32) for all items (n = 33).

Test Food	Liking		Familiarity	
	Median	IQR	Median	IQR
Carton of fresh orange juice	91.0	24.3	97.3	16.3
Pork pies	24.8	60.8	76.8	53.9
Cheese and crackers	79.5	45.6	93.5	14.6
Cola drink	76.3	43.1	98.0	10.1
Whole milk	28.0	48.5	93.0	29.0
Hot chocolate	77.8	44.5	94.5	20.6
Peanut butter on toast	27.0	85.0	88.3	53.8
Country vegetable soup	82.0	46.0	89.3	47.0
Fruit salad	82.5	33.4	91.8	14.9
Light vanilla yoghurt	67.3	50.9	78.0	51.5
A banana	90.5	27.5	97.3	8.6
Croissant	82.3	43.0	92.8	26.5
Chicken salad bowl with a caesar dressing	65.5	56.3	92.0	29.6
Biscuit cereal with semi-skimmed milk	87.0	34.9	96.5	7.8
Instant chicken flavoured noodles	69.8	38.9	94.5	22.1
Flapjack	83.0	28.9	94.8	19.8
Chocolate bar	95.3	15.8	98.0	7.0
Blueberry muffin	68.5	48.0	95.5	26.5
Cereal breakfast bar	81.3	45.5	95.0	10.3
Cottage cheese on crispbreads	24.5	55.0	78.8	82.5
Sausage roll	84.8	44.1	95.8	11.3
Beans and cheese on toast	80.8	45.0	95.8	10.1
Malt loaf	41.8	78.4	77.5	45.5
Crisps	76.5	29.5	96.5	12.4
Peanuts	76.3	39.3	95.0	14.8
Macaroni and cheese	49.5	65.8	73.3	47.4
Chicken in black bean sauce with rice	67.8	34.5	81.3	35.6
Cottage pie with broccoli and carrots	89.3	31.9	94.0	18.4
Ice cream	91.8	27.8	97.0	6.6
Chicken sandwich roll, chocolate bar and a can of cola drink	78.3	21.8	91.3	12.2
Meat and barbeque sauce pizza with a garlic and herb dip	76.8	57.4	85.5	52.8
Cheese & ham quiche and coleslaw	43.3	62.6	83.0	61.3
Bacon and cheese panini, crisps and cranberry juice	70.8	19.9	91.9	27.6

3.4 Baseline appetite measures

To compare baseline mean hunger, fullness and thirst VAS ratings across test weeks, as a whole group and by sex group, a one-way repeated measures ANOVA was carried out using the Bonferonni correction.

For hunger, assumptions of normality and sphericity were met. Results showed that there were no significant differences in baseline hunger, within subjects, across the three test days [$F_{(2, 60)} = 0.410$, $p = 0.665$] or between sex groups ($p = 0.193$).

For fullness, assumptions of normality and sphericity were met. Results showed that there were no significant differences in baseline fullness, within subjects, across the three test days [$F_{(2, 60)} = 0.256$, $p = 0.775$] or between sex groups ($p = 0.140$).

For thirst, assumption of normality was met, but sphericity was violated, therefore the Greenhouse-Geisser correction was used. Results showed that there were no significant differences in baseline thirst, within subjects, across the three test days [$F_{(1.6, 48.4)} = 0.035$, $p = 0.940$] or between sex group ($p = 0.846$).

These results confirm the effectiveness of the study protocol in standardising baseline appetite levels, the participants' compliance with this protocol and the robustness of the data.

3.5. Portion estimates

3.5.1. Portion estimates across all foods

The distribution of mean portion estimates across all foods are shown for the whole group in **Figure 1**, and by male and female sex group in **Figures 2** and **3**, respectively. Most foods were estimated at 1 to 1.5 portions, with a median portion estimate of 1.2 (0.8 – 2.9). By sex group males estimated more foods (8 foods) at 0.5 to 1 portion than females (4 foods), and females estimated more foods (8 foods) at 1.5 portion or more than males (3 foods). In other words portion estimation in males (1.1 (0.7 – 2.2)) were on average lower than in females (1.2 (0.8 – 3.5)).

As portion estimates were non-normally distributed for most foods a Mann-Whitney test was conducted to compare the differences in mean portion estimation between sex group across all foods. Results showed a significant difference in mean portion estimation (±SEM)

between sex group for: milk [female mean (n=17) = 2.3 (± 0.23), male mean (n=15) = 1.3 (±0.12), p = 0.001]; chocolate bar [female mean (n=17) = 1.9 (± 0.11), male mean (n=15) = 1.4 (±0.15), p = 0.008]; sausage roll [female mean (n=17) = 2.1 (± 0.29), male mean (n=15) = 1.2 (±0.11), p = 0.003] and ice cream [female mean (n=17) = 3.5 (± 0.32), male mean (n=15) = 2.2 (±0.24), p = 0.007]. These results also revealed trends in differences in mean portion estimations (±SEM) between sex group for: cheese and crackers [female mean (n=17) = 2.3 (± 0.42), male mean (n=15) = 1.4 (±0.13), p = 0.076] and peanuts [female mean (n=17) = 1.7 (± 0.25), male mean (n=15) = 1.1 (±0.16), p = 0.069]. Overall, results showed that the mean female estimated portion was significantly higher than the mean male estimated portion, for all foods where significance was found. Results also showed that the mean female estimated portion was higher than the mean male estimated portion, for all foods where trends were found. Finally where a significance or trend was shown between sex group differences in food portion estimates, these items were all labelled as snack foods and were of high or medium energy density, with the exception of whole milk which was labelled as a drink and was of very low-energy density.

Figure 1. Mean portion estimates (±SEM) across all foods/drinks for the whole group (*n*=32).

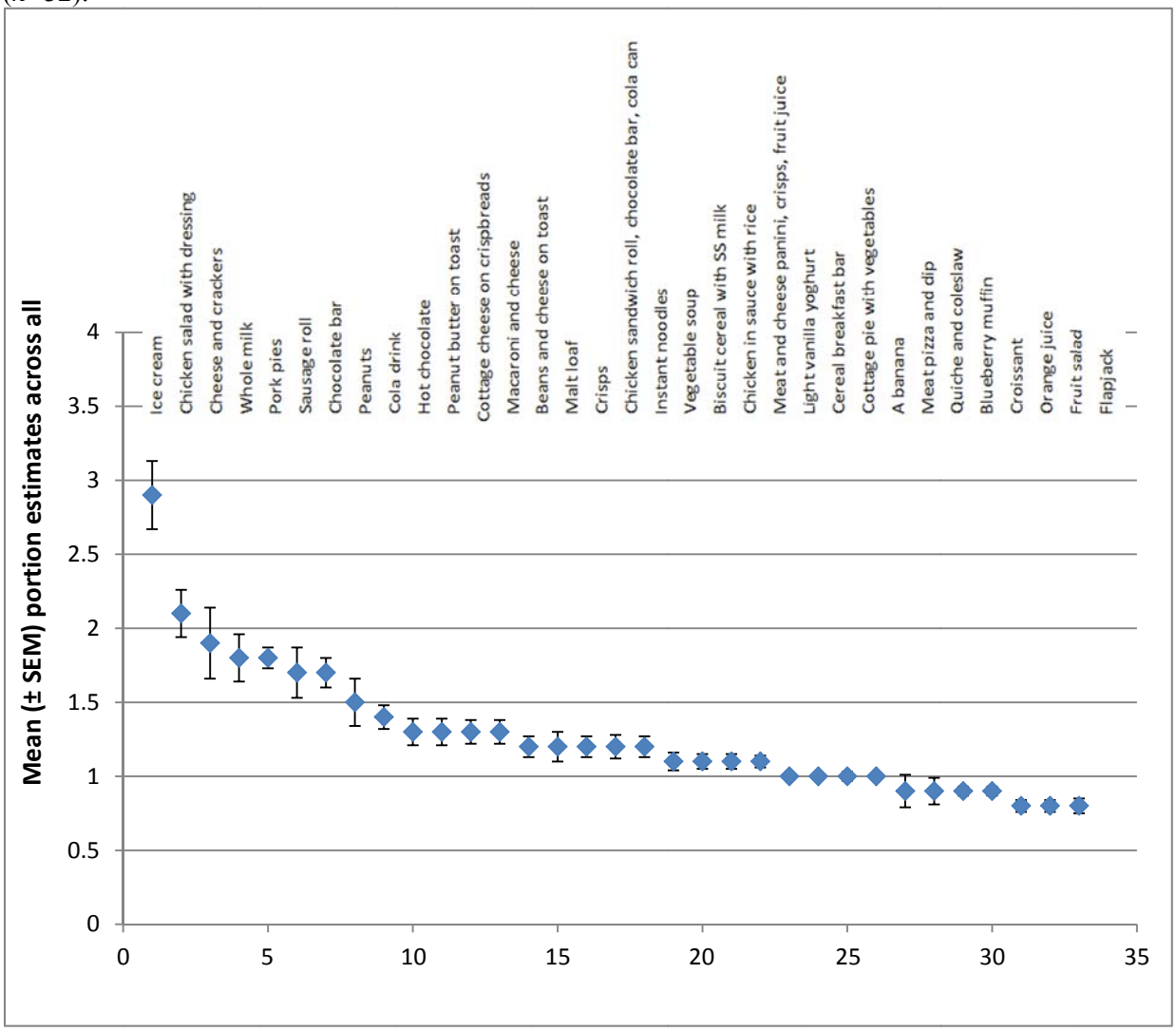


Figure 2. Mean portion estimates (±SEM) across all foods/drinks for males (*n*=15).

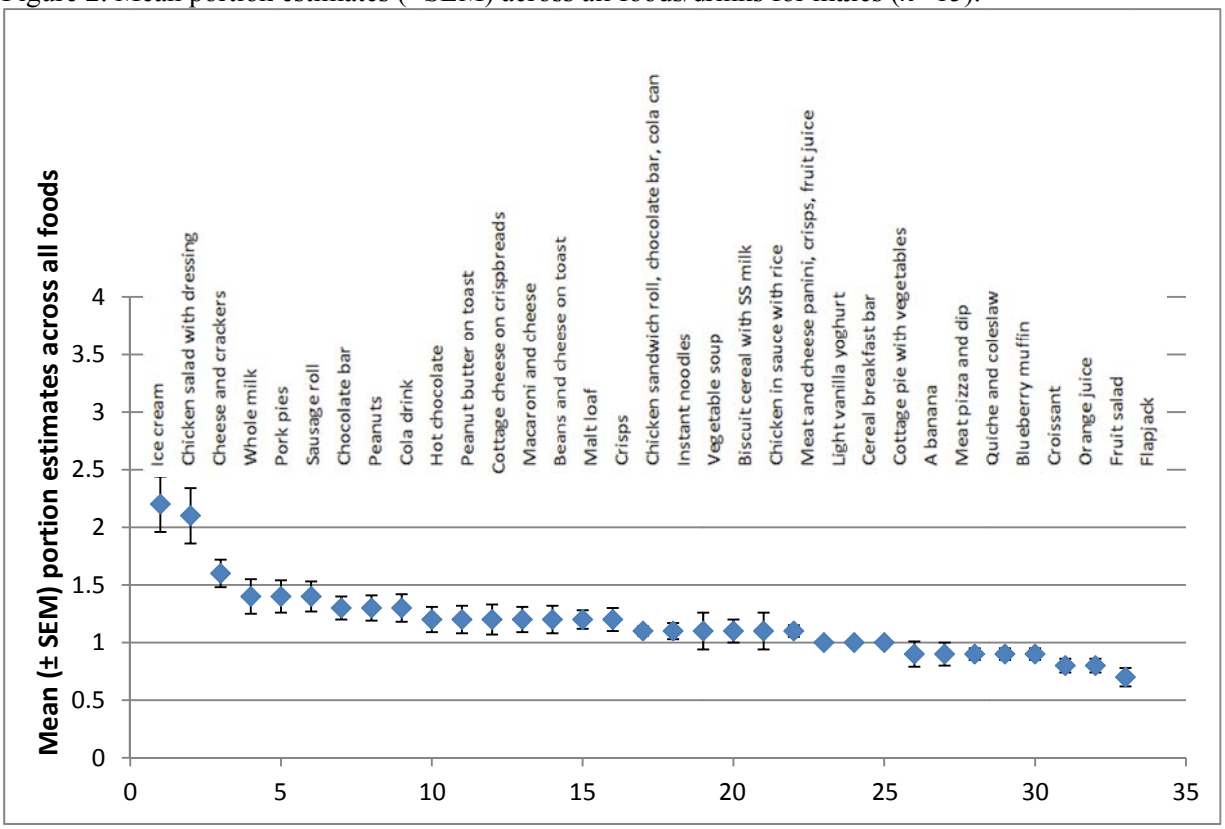
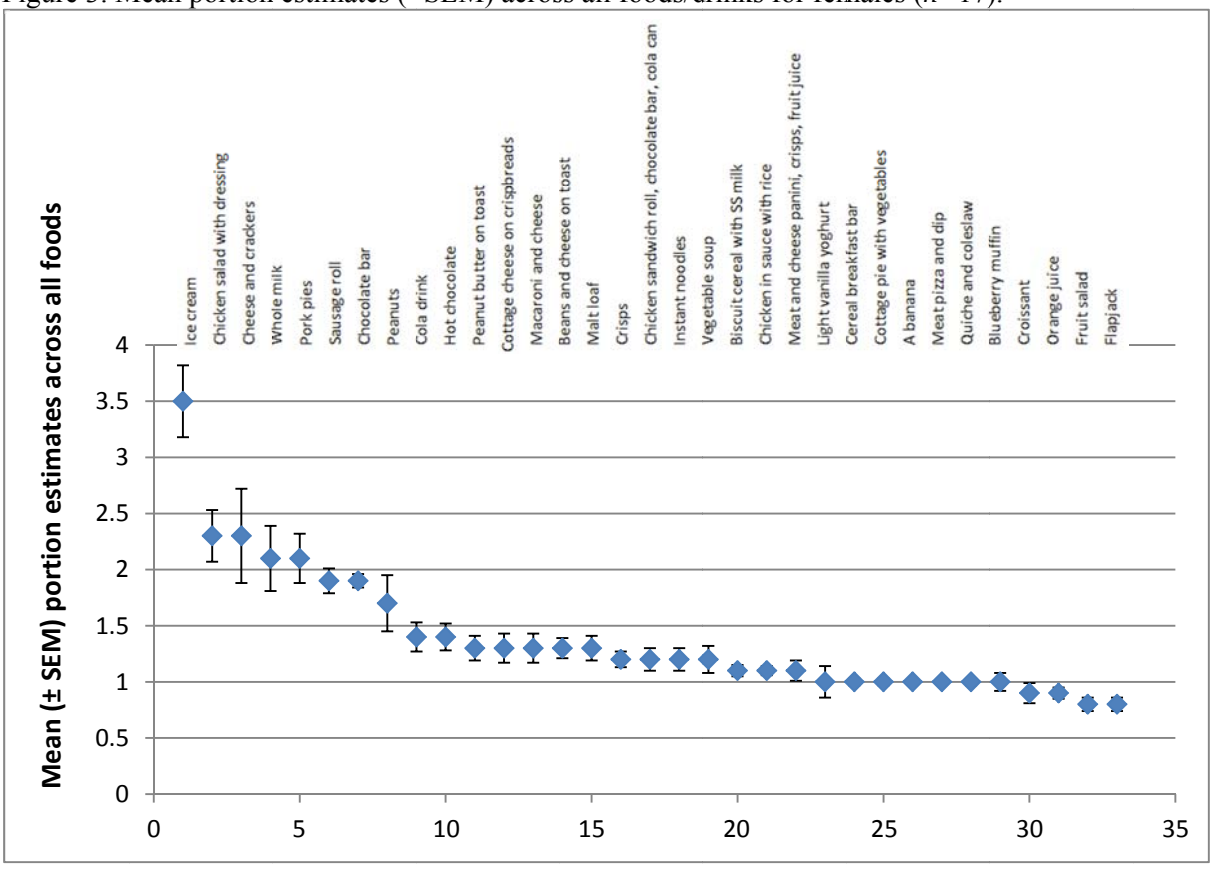


Figure 3. Mean portion estimates (±SEM) across all foods/drinks for females (*n*=17).



3.4.2. Portion estimates across food types and food unit size

Mean portion size estimates for the whole group (n=32) between food types (snacks vs. non-snack meals and beverages) were compared using the Wilcoxon test, as the mean portion estimates were non-normally distributed for the non-snacks meals and beverages food type. Results showed that there were no significant differences ($p = 0.571$) in mean portion estimates between the snack group (n=16) and the non-snack meals and beverages group (n=17). This result indicates that food portion sizes in foods labelled "as a snack", "as a meal" or "as a beverage", were not estimated differently in this sample of subjects.

Mean portion size estimates for the whole group (n=32) between food units (single unit foods vs. multi-item foods) were compared using the Wilcoxon test, as the mean portion estimates were non-normally distributed for the multi-item foods category. Results showed that there were no significant differences ($p = 0.593$) in mean portion estimates between the single unit foods group (n=21) and the multi-item foods group (n=12). This result indicates that the portion sizes of foods presented in single unit or as multi-items were not estimated differently in this sample of subjects.

3.4.3. Portion size reference amounts

This study included multi-component foods, some of which were not listed in the FSA portion size reference book (Crawley, 2002). It was therefore necessary to look up the individual components of the items to calculate the reference portion size for 1 portion of the item. This was done by calculating the sum of the portion size of each food item in the meal (by FSA standards) and dividing it by the number of items in the meal (**Table 3**).

The FSA portions size reference amounts were then compared against the mean portion size estimates for all foods (**Figure 4**). This shows that the majority of foods corresponding to more than 1 FSA reference portion were underestimated (i.e. their portion size was estimated as smaller than the reference amount), with the exception of chocolate

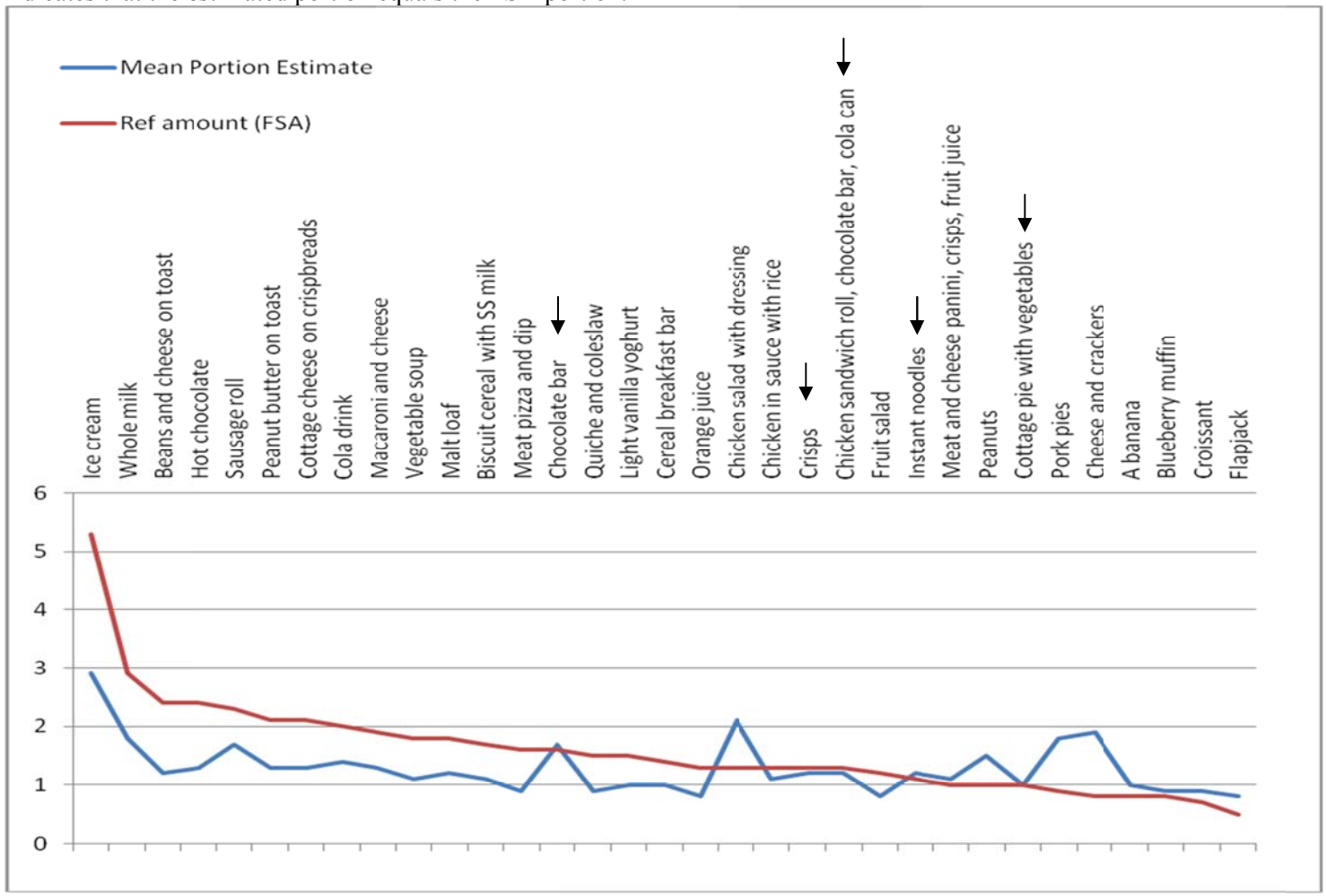
bar whose estimated portion size was equal to the reference amount and chicken salad with dressing whose portion size was estimated as larger than the reference amount. On the other hand all foods presented with a portion smaller than or equal to 1 FSA reference portion were overestimated (i.e. their portion size was estimated as larger than the reference amount) with the exception of cottage pie with vegetables which was accurately estimated.

Table 3. Results of the calculation of Food Standards Agency (FSA) 2002 (Crawley, 2002) portion reference amounts for non-listed items.

Foods		FSA portion size of each foods displayed (g)	Portion size of each foods displayed (g)	Portion size based on the FSA for each item	Portion size based on the FSA for multi-item meal total[a]
Cheese and crackers	Cheese	40	30	0.75	0.8
	Crackers	33	25	0.76	
Peanut butter on toast	Peanut butter	25	20	0.80	2.1
	Toast	22	72.4	3.30	
Chicken salad bowl with a caesar dressing	Chicken	130	230	1.77	1.3
	Salad	80	75	0.94	
	Caesar dressing	15	20	1.33	
Biscuit cereal with semi-skimmed milk	Biscuit cereal	20	37.5	1.88	1.7
	Semi-skimmed milk	100	155	1.55	
Cottage cheese on crispbreads	Cottage cheese	112	125	1.12	2.1
	Crispbreads	10	30	3.00	
Beans and cheese on toast	Beans	135	420	3.11	2.4
	Cheese	40	30	0.75	
	Toast	22	72.4	3.29	
Cottage pie with broccoli and carrots	Cottage pie	310	300	0.97	1.0
	Broccoli	85	160	1.10	
	Carrots	60 (total 145)			
Chicken sandwich roll, chocolate bar and a can of cola drink	Chicken sandwich roll	130	167	1.28	1.3
	Chocolate bar[1]	56	85	1.52	
	Cola drink	343.2	343.2	1.00	
Meat and barbeque sauce pizza with a garlic and herb dip	Meat and barbeque sauce pizza	200	160	0.8	1.6
	Garlic and herb dip	12	28	2.3	
Cheese & ham quiche and coleslaw	Cheese & ham quiche	140	100	0.71	1.5
	Coleslaw	45	100	2.22	
Bacon and cheese panini, crisps and cranberry juice	Bacon and cheese panini	130	145	1.12	1.0
	Crisps	40	25	0.63	
	Cranberry juice	160	208	1.30	

[a] 1 portion of meal calculated as: sum of portion size of each food item in meal (FSA) / number of items in meal

Figure 4. Comparison of mean portion estimates (n=32) with Food Standard Agency (FSA) 2002 (Crawley, 2002) portion reference amounts for all foods. ↓ indicates that the estimated portion equals the FSA portion.



Differences in mean portion size estimation and the Food Standards Agency (FSA) portion size reference amounts for all foods (n=33) were compared using a One-Sample Wilcoxon Signed Ranks Test (**Table 4**). Results showed that there were no significant differences ($p>0.05$) between the mean estimated portion size and the FSA reference amount in 5 items including instant chicken flavoured noodles ($p = 0.413$), chocolate bar ($p = 0.925$), crisps ($p = 0.077$), cottage pie with broccoli and carrots ($p = 0.334$) and chicken sandwich roll, chocolate bar and can of cola drink meal ($p = 0.087$). This means that the mean estimated portion sizes for these foods can be considered equal to that of the FSA portion size reference amount.

For the remaining foods there was a significant difference between the mean estimated portion size and the FSA reference amount ($p<0.05$). These foods can be divided into two categories, those which were significantly overestimated and those which were significantly underestimated compared to the FSA portion size reference amount. This difference in estimation was calculated according to the direction of percentage error of estimation.

According the FSA standards 9 items were significantly overestimated including pork pies, cheese and crackers, banana, croissant, chicken salad bowl with a caesar dressing, flapjack, blueberry muffin, peanuts and bacon and cheese Panini, crisps and cranberry juice meal.

The remaining 24 items were significantly underestimated including orange juice, cola drink, whole milk, hot chocolate, peanut butter on toast, country vegetable soup, fruit salad, light vanilla yoghurt, biscuit cereal with semi-skimmed milk, cereal breakfast bar, cottage cheese on crispbreads, sausage roll, beans and cheese on toast, malt loaf, macaroni and cheese, chicken in black bean sauce with rice, ice cream, meat and barbeque sauce pizza with a garlic and herb dip and cheese and ham quiche with coleslaw.

These results show that the estimation of portion size close to the FSA standard occurred in both snack foods (2 items) and non-snack meals (3 items), as well as in both

single unit foods (3 items) and multi-item foods (2 items). Accuracy in estimation was also seen across low (1 item), medium (2 items) and high (2 items) energy densities.

Overestimation of foods occurred in both snack foods (7 items) and non-snack meals (2 items), as well as in both single unit foods (6 items) and multi-item foods (3 items). Overestimation was also seen across low (2 items), medium (1 items) and high (6 items) energy densities.

Underestimation of foods occurred in both snack foods (7 items) and non-snack meals (8 items) and all beverages (4 items), as well as by food unit, i.e. in both single unit foods (12 items) and multi-item foods (7 items). Underestimation was also seen across very-low (4 items), low (8 items), medium (5 items) and high (2 items) energy densities.

Overall, these results show that differences in accuracy of portion size estimation vs. FSA standard occurred across all food types, food unit sizes and energy density of foods.

Table 4. Comparison of mean portion estimates (n=32) with Food Standards Agency (FSA) reference amounts (Crawley, 2002) for all foods using one sample Wilcoxon test.
Abbreviations: SEM, standard error of the mean.

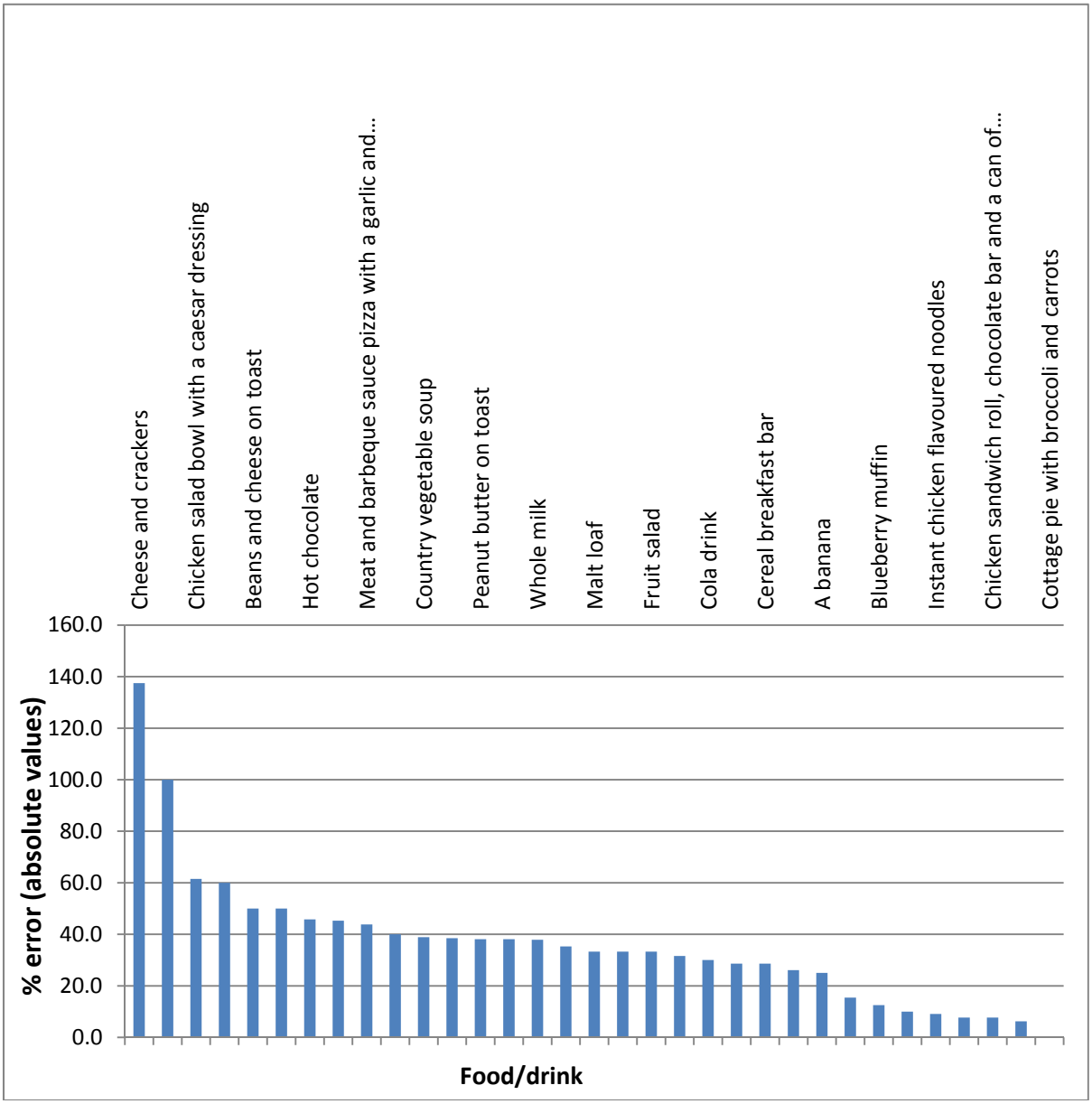
Food/Drink	Standard portion size (FSA)	Mean estimate (± SEM)	*p* value
Carton of fresh orange juice	1.3	0.8 (± 0.04)	P = 0.000
Pork pies	0.9	1.8 (± 0.07)	P = 0.000
Cheese and crackers	0.8	1.9 (± 0.24)	P = 0.000
Cola drink	2.0	1.4 (± 0.82)	P = 0.000
Whole milk	2.9	1.8 (± 0.16)	P = 0.000
Hot chocolate	2.4	1.3 (± 0.09)	P = 0.000
Peanut butter on toast	2.1	1.3 (± 0.09)	P = 0.000
Country vegetable soup	1.8	1.1 (± 0.06)	P = 0.000
Fruit salad	1.2	0.8 (± 0.04)	P = 0.000
Light vanilla yoghurt	1.5	1.0 (± 0.02)	P = 0.000
A banana	0.8	1.0 (± 0.00)	P = 0.000
Croissant	0.7	0.9 (± 0.03)	P = 0.000
Chicken salad bowl with a caesar dressing	1.3	2.1 (± 0.16)	P = 0.000
Biscuit cereal with semi-skimmed milk	1.7	1.1 (± 0.05)	P = 0.000
Instant chicken flavoured noodles	1.1	1.2 (± 0.07)	P = 0.413
Flapjack	0.5	0.8 (± 0.05)	P = 0.000
Chocolate bar	1.6	1.7 (± 0.10)	P = 0.925
Blueberry muffin	0.8	0.9 (± 0.03)	P = 0.004
Cereal breakfast bar	1.4	1.0 (± 0.02)	P = 0.000
Cottage cheese on crispbreads	2.1	1.3 (± 0.08)	P = 0.000
Sausage roll	2.3	1.7 (± 0.17)	P = 0.000
Beans and cheese on toast	2.4	1.2 (± 0.07)	P = 0.000
Malt loaf	1.8	1.2 (± 0.10)	P = 0.000
Crisps	1.3	1.2 (± 0.07)	P = 0.077
Peanuts	1.0	1.5 (± 0.16)	P = 0.004
Macaroni and cheese	1.9	1.3 (± 0.08)	P = 0.000
Chicken in black bean sauce with rice	1.3	1.1 (± 0.05)	P = 0.000
Cottage pie with broccoli and carrots	1.0	1.0 (± 0.03)	P = 0.334
Ice cream	5.3	2.9 (± 0.23)	P = 0.000
Chicken sandwich roll, chocolate bar and a can of cola drink	1.3	1.2 (± 0.08)	P = 0.087
Meat and barbeque sauce pizza with a garlic and herb dip	1.6	0.9 (± 0.11)	P = 0.000
Cheese & ham quiche and coleslaw	1.5	0.9 (± 0.09)	P = 0.000
Bacon and cheese panini, crisps and cranberry juice	1.0	1.1 (± 0.04)	P = 0.040

3.5. Percent error in estimations

3.5.1. Distribution of percent error of estimates across all foods

The absolute percentage error of mean portions estimated across all foods based on FSA standards are shown for the whole group in **Figure 5**. This highlights that most foods had a percentage error of portion size estimation between 20-50%, this percentage error refers to the degree of portion size "misestimation" compared to the reference standard and not the direction of the "error".

Figure 5. Absolute percentage error of mean portions estimated for the whole group (n=32) across all foods/drinks based on FSA standards.



To analyse the effect of sex group on percentage error in estimation (with both absolute and actual values) a Mann-Whitney analysis was performed to compare the percentage error in estimation across all foods, between males and females. For the actual value no significant differences were detected ($p = 0.251$), indicating that there was no difference between percentage error in estimation by sex group. The same results were found when absolute values were used ($p = 0.626$).

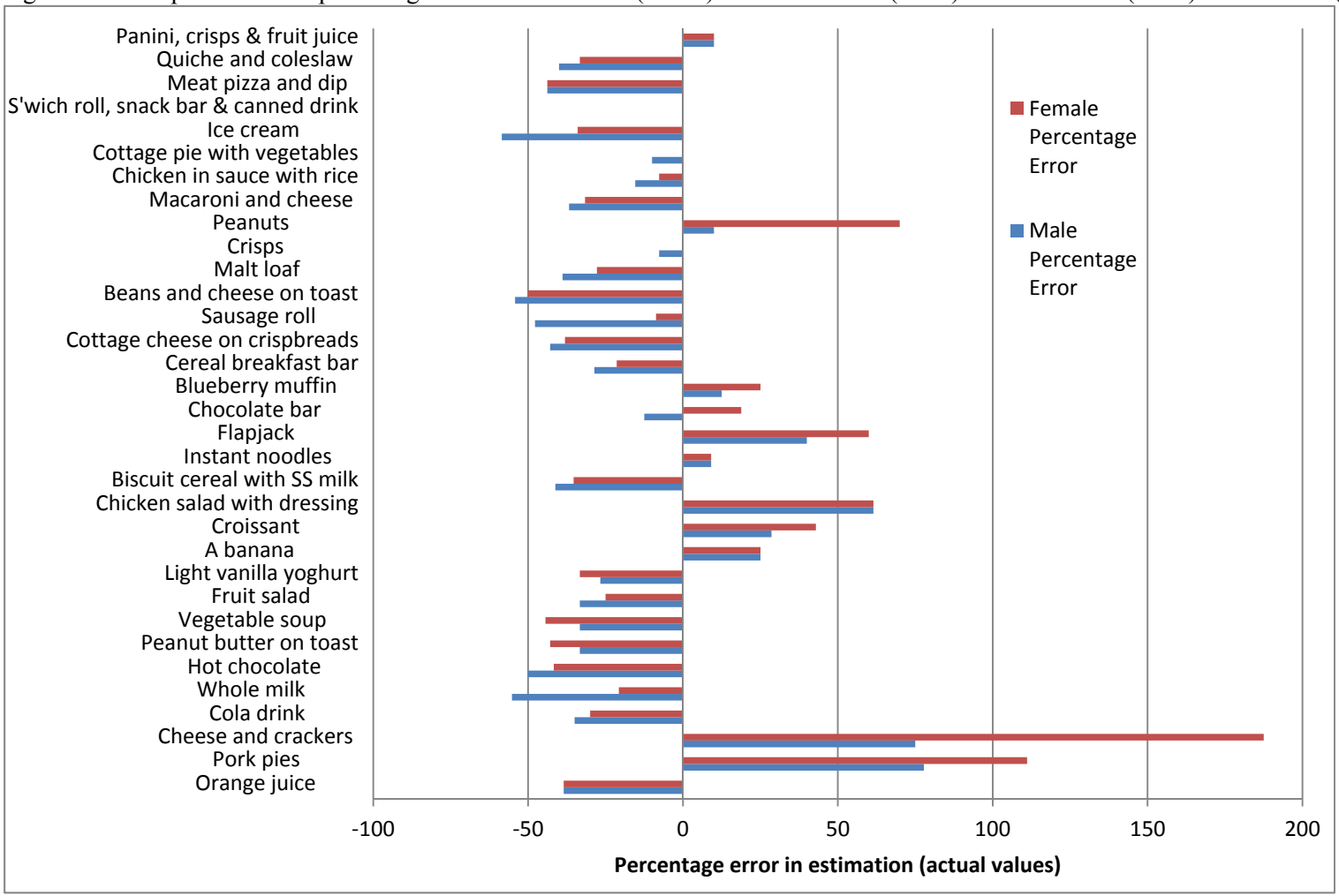
The median and interquartile range for both actual and absolute values are shown in **Table 5** for each sex group. For both actual and absolute values the median percentage errors in females were lower than males, although these differences were not significant.

Actual percentage error in estimation by males and females were of the same direction whether overestimated or underestimated. The only exception to this was the chocolate bar, which was underestimated in males and overestimated in females (**figure 6**).

Table 5. The median and interquartile range for actual and absolute percentage error in estimation for both males and females.

	Actual Percentage Error in Estimation		Absolute Percentage Error in Estimation	
	Median	Interquartile Range	Median	Interquartile Range
Males	-28.6	50.6	35.0	31.9
Females	-20.7	56.6	33.3	23.6

Figure 6. A comparison in the percentage error in estimation (actual) across all foods (n=33) between males (n=15) and females (n=17).



3.5.2. Differences in percent error of estimation between food types and food unit size

Percentage error (actual values) of portion size estimates for the whole group (n=31) and sex group (15 males, 17 females) between food types (snacks vs. non-snack meals and beverages) were compared using the Wilcoxon test, as the mean portion estimates were non-normally distributed for the non-snack meals and beverages food type. The medians and interquartile range for actual values are shown in **Table 6** for each food type by whole group and sex groups. Results showed that there was a significant difference ($p = 0.047$) in actual percentage error for the whole group between the snack group (n=16) and non-snack meals and beverages group (n=17). Analysis by sex group indicated a significant difference ($p = 0.036$) for females, but only a trend for males ($p = 0.088$) in actual percentage error. These results indicate that actual percentage error in foods labelled "as a snack", "as a meal" or "as a beverage", were estimated differently in this sample of subjects, with food labelling having a greater affect in females than males.

Table 6. Actual percentage error of estimation medians and interquartile range of foods, by food type, whole group and sex group.

	Median (IQR)		
	Whole group	Males	Females
Snacks	-0.8 (77.9)	-10.1 (65.2)	9.4 (82.8)
Non-Snacks	-35.3 (35.6)	-35.0 (37.5)	-31.6 (42.3)

The percentage error of portion size estimates (using the absolute values) was also analysed between food types. The median and interquartile range (absolute values), are shown in **Table 7** for each food type, by whole group and sex groups. Results showed that there were no significant differences ($p = 0.691$) in percentage error for the whole group. Analysis by sex group confirmed these results (males ($p = 0.918$) and females ($p = 0.426$)). These results indicate that the percentage error of estimates in foods labelled "as a snack",

"as a meal" or "as a beverage", were not estimated differently in this sample of subjects, or by sex group when using absolute values.

Table 7. Absolute percentage error of estimation median and interquartile range of foods, by food type, whole group and sex group.

	Median (IQR)		
	Whole group	Males	Females
Snacks	33.3 (23.6)	40.0 (30.9)	30.6 (33.4)
Non-Snacks	37.9 (29.2)	36.8 (34.2)	33.3 (33.8)

Percentage error (actual values) of portion size estimates for the whole group (n=31) and sex group (15 males, 17 females) between food units (single unit foods vs. multi-item foods) were compared using the Wilcoxon test, as the mean portion estimates were non-normally distributed for the multi-item food unit. The percentage error of estimation median and interquartile range for actual values, are shown in **Table 8** for each food unit, by whole group and sex groups. Results showed that there were no significant differences ($p = 0.638$) in percentage error for the whole group between the single units foods group (n=21) and multi-item foods group (n=12). Analysis by sex group also showed no significant difference for neither females ($p = 0.583$) or males ($p = 0.583$) in percentage error. These results indicate that the percentage error of estimates in foods displayed as either a single unit or a multi-item food were not estimated differently in this sample of subjects.

Table 8. Actual percentage error of estimation median and interquartile range of foods, by food unit, whole group and sex group.

	Median (IQR)		
	Whole group	Males	Females
Single	-28.6 (54.4)	-28.6 (50.0)	-20.7 (57.5)
Multi-item	-25.4 (47.0)	-24.4 (50.0)	-20.5 (49.2)

Percentage error of portion size estimates (absolute values) were also analysed between food units. The percentage error of estimation median and interquartile range for absolute values, are shown in **Table 9** for each food unit, by whole group and sex groups. Results showed that there were no significant differences ($p = 0.875$) in percentage error for the whole group. Analysis by sex group also showed no significant difference for males ($p = 0.875$) or females ($p = 0.969$) in percentage error. These results indicate that the percentage error of estimates in foods displayed as either a single unit or a multi-item food were not estimated differently in this sample of subjects, or by sex group when using absolute values.

Table 9. Absolute percentage error of estimation median and interquartile range of foods, by food unit, whole group and sex group.

	Median (IQR)		
	Whole group	Males	Females
Single	33.3 (16.5)	33.3 (25.2)	30.0 (21.3)
Multi-item	38.1 (37.1)	40.6 (40.3)	36.7 (40.2)

3.5.3. The effect of energy density category on actual percentage error of estimates

The effects of differences across energy densities on actual percentage error of estimation were compared using Kruskal-Wallis tests, as both energy density categories and the percentage error of estimates were non-normally distributed. For the whole group (n=31) the K-W test gave an χ^2 of 8.313 with an associated probability value of 0.040. Thus it was concluded that there was a significant difference in the percentage error of estimations across energy density category, in this sample of subjects.

The effects of differences across energy densities on actual percentage error of estimation were then analysed within sex group, again using the Kruskal-Wallis test. The percentage error of estimations median and interquartile range for actual values, are shown in **Table 10** for each energy density category, by whole group and sex groups.

Results showed that there was a significant association in both males ($\chi^2 = 8.013$, p = 0.046) and females ($\chi^2 = 8.938$, p = 0.030). This means that the percentage error of estimation (actual) were different for foods having a HED, MED, LED or VLED in this sample of subjects as a whole (n=32) and by gender.

Table 10. Actual percentage error of estimation median and interquartile range of foods, by energy density category, whole group and sex group ("+" = overestimation, "-" = underestimation).

	Median (IQR)		
Energy density category	Whole group	Males	Females
1	-35.6 (16.1)	-34.2 (20.2)	-31.7 (24.5)
2	-32.5 (58.1)	-35.1 (62.7)	-28.3 (56.9)
3	-33.3 (39.8)	-38.9 (49.9)	-27.8 (40.6)
4	+20.5 (82.9)	+11.3 (65.3)	+34.0 (85.6)

The effects of differences across energy densities on absolute percentage error of estimation were also analysed. The K-W test for the whole group (n=32) gave a χ^2 of 1.196 with an associated probability value of 0.754, that is non-significant association between the two variables in both male ($\chi^2 = 1.110$, p = 0.775) and female ($\chi^2 = 3.406$, p = 0.333) sex groups. Thus it was concluded that when using absolute values there was no significant difference in the percentage error of estimations across energy density category, in this sample of subjects, for the whole group and by sex group. The percentage error of estimations median and interquartile range for absolute values, are shown in **Table 11** for each energy density category, by whole group and sex groups.

Table 11. Absolute percentage error of estimation median and interquartile range of foods, by energy density category, whole group and sex group.

	Median (IQR)		
Energy density category	Whole group	Males	Females
1	35.6 (16.1)	34.2 (20.2)	31.7 (24.5)
2	34.3 (22.3)	39.0 (26.1)	33.5 (22.9)
3	33.3 (29.5)	38.9 (35.8)	27.8 (27.2)
4	36.2 (58.7)	28.6 (39.7)	43.4 (59.5)

3.6. Relationship between percent error in estimates and energy density

3.6.1. Categorisation of energy density variable

In order to interpret the potential role of energy density on portion size estimation across food groups the energy densities of all food items were re-coded into four energy density categories (category 1 = ≤0.64 kcal/g; category 2 = 0.65-1.44 kcal/g; category 3 = 1.45-3.94 kcal/g; category 4 = ≥3.95 kcal/g) based on Rolls & Barnett system (2000). The distribution of this energy density variable showed a similar number of foods in each group, with slightly more foods on the higher energy density category (category 4).

3.6.2. Spearman's correlation analyses across all foods

The correlation between percent error in estimates and energy density was analysed across all foods using the Spearman's rank correlation test. Analysis for actual percent error vs. energy density values (kcal/g) showed a significant correlation (rho = 0.404, p = 0.020) (**Figure 7a**). The same results were found for actual percent error vs. energy density category (1-4) (rho = 0.439, p = 0.011).

The correlation between absolute percent error vs. energy density values (kcal/g) was also analysed. The Spearman's rank test was non-significant (rho = 0.062, p = 0.732) (**Figure 7b**), the same results were found for absolute percent error vs. energy density category (1-4) (rho = 0.043, p = 0.811).

Figure 7a. Energy density and percentage error (actual values) of mean portion estimates across all foods/drinks for the whole group (*n*=32).

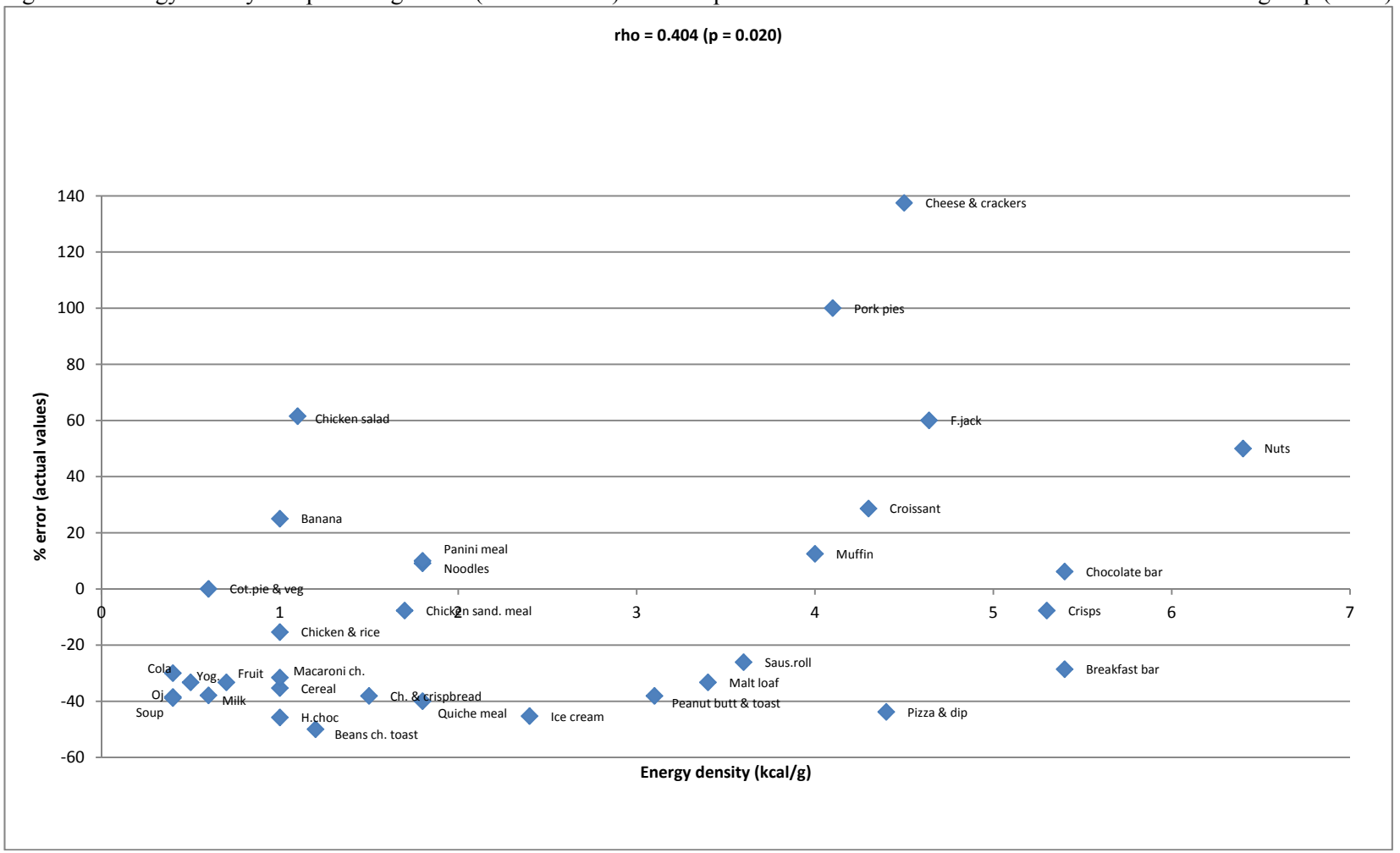
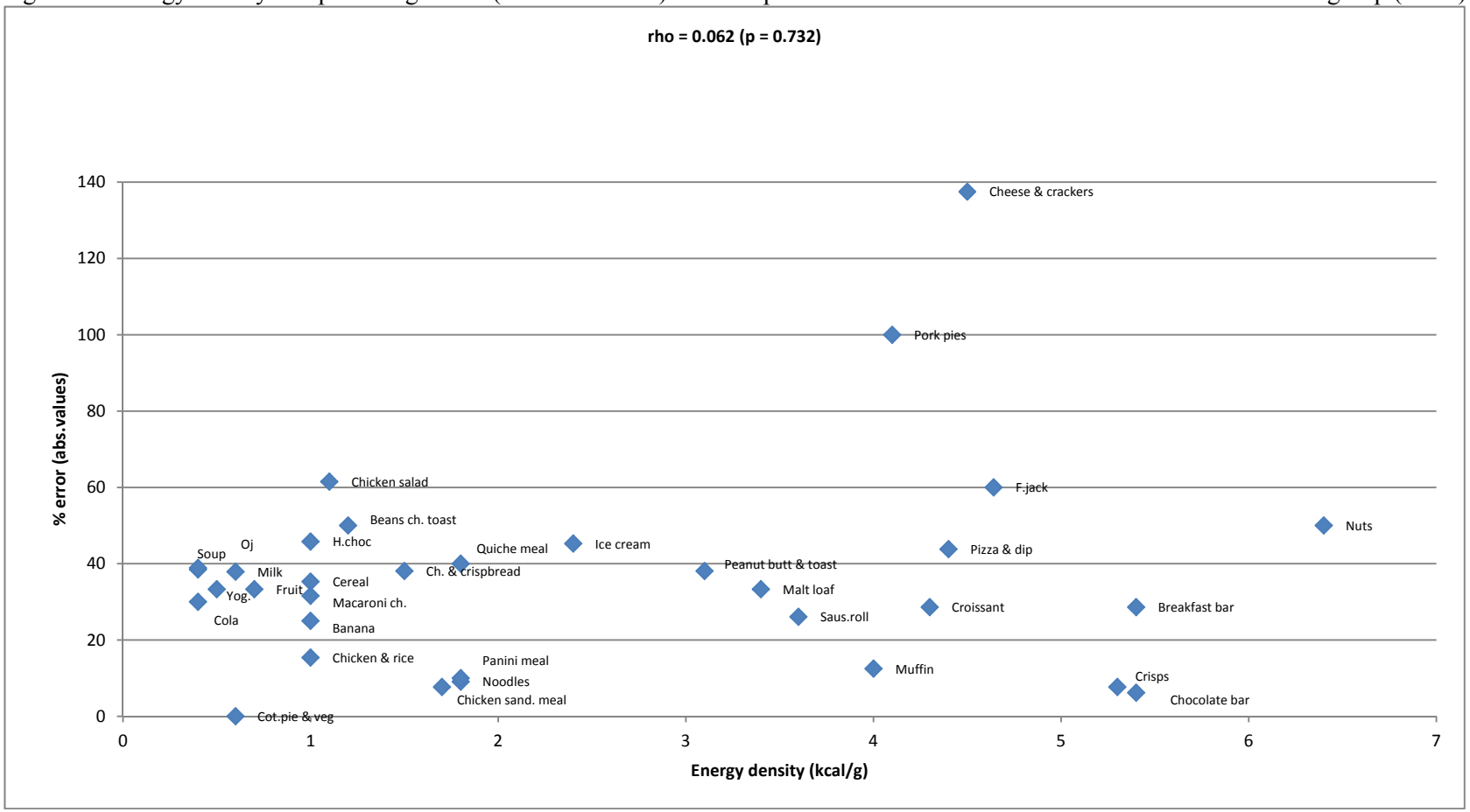


Figure 7b. Energy density and percentage error (absolute values) of mean portion estimates across all foods/drinks for the whole group (*n*=32).



3.6.3. Spearman's correlation analyses for food type and food unit size

The correlation between actual percent error in estimates and energy density (kcal/g) was analysed according to food type (snacks only; non-snack meals and beverages only) and food unit (single unit foods only; multi-item foods only) using Spearman's rank correlation test.

Analysis by food type showed a significant correlation between actual values for snacks (rho = 0.546, p = 0.029) (**Figure 8a**), whilst no significant correlation using actual values was shown for non-snack meals and beverages (rho = -0.002, p = 0.993) (**Figure 8b**). Analysis by food unit showed a significant correlation between actual values for single unit foods (rho = 0.576, p = 0.006) (**Figure 9a**), whilst no significant correlation using actual values was shown for multi-item foods (rho = 0.133, p = 0.680) (**Figure 9b**).

Correlation analyses by food type was non-significant using absolute percentage error values for both snacks (rho = -0.047, p = 0.862) (**Figure 10a**) and non-snack meals and beverages (rho = 0.100, p = 0.701) (**Figure 10b**). Correlation analyses by food unit was non-significant when using absolute percentage error values for single unit foods (rho = -0.256, p = 0.263) (**Figure 11a**), whilst a significant correlation using absolute values was shown for multi-item foods (rho = 0.687, p = 0.014) (**Figure 11b**).

Figure 8a. Energy density and percentage error (actual values) of mean portion estimates across snacks only for the whole group (*n*=32).

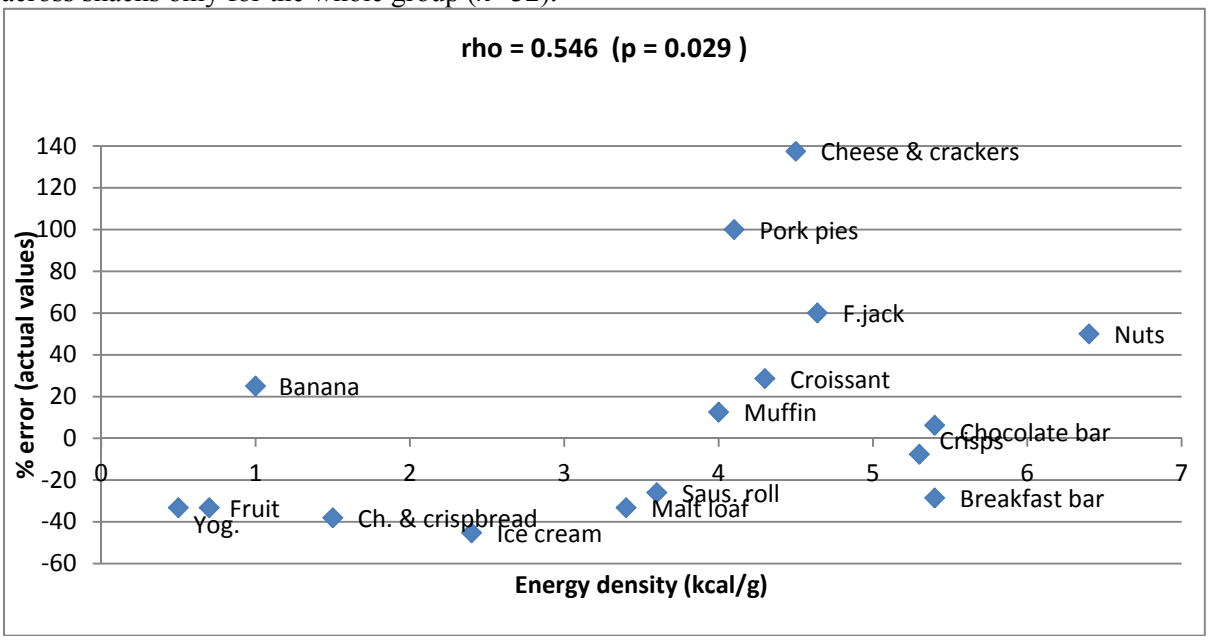


Figure 8b. Energy density and percentage error (actual values) of mean portion estimates across all non-snack meals and beverages for the whole group (*n*=32).

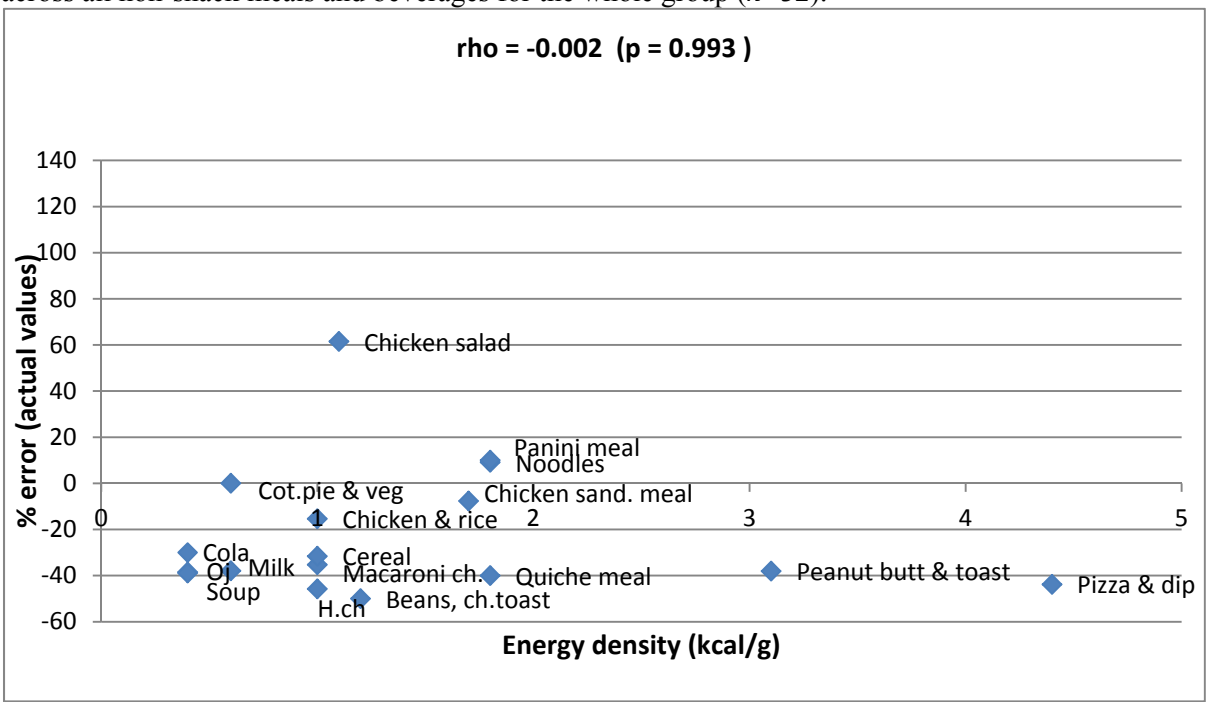


Figure 9a. Energy density and percentage error (actual values) of mean portion estimates across single unit foods only for the whole group (*n*=32).

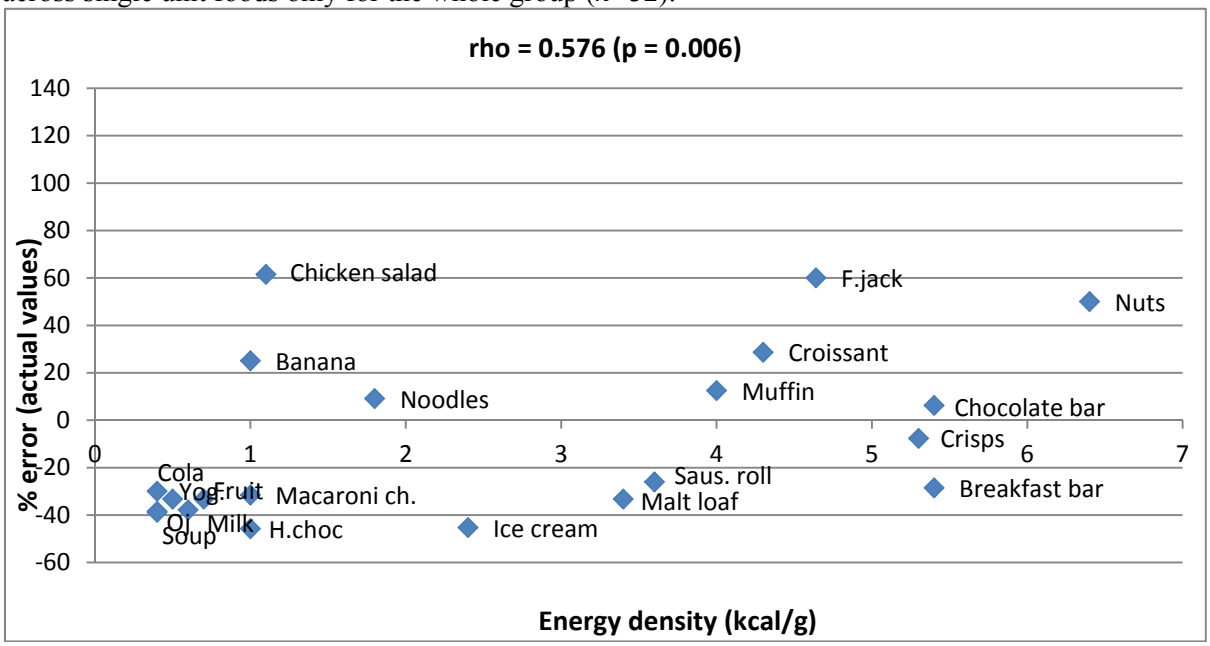


Figure 9b. Energy density and percentage error (actual values) of mean portion estimates across multi-item foods only for the whole group (*n*=32).

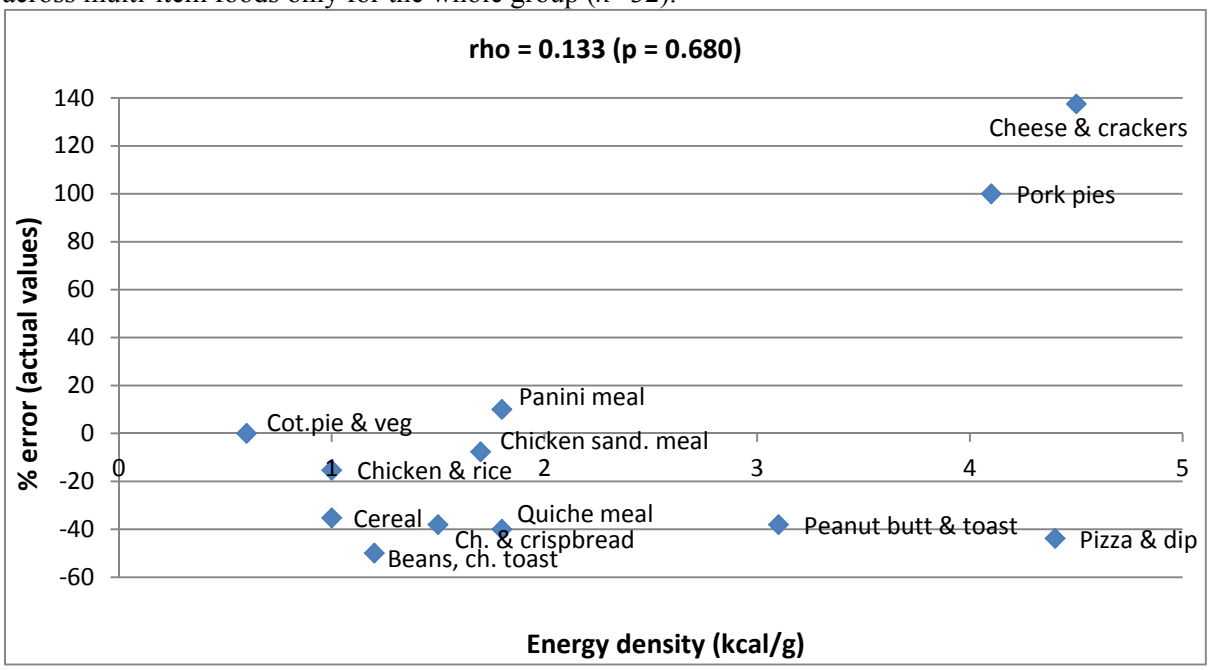


Figure 10a. Energy density and percentage error (absolute values) of mean portion estimates across snacks only for the whole group (*n*=32).

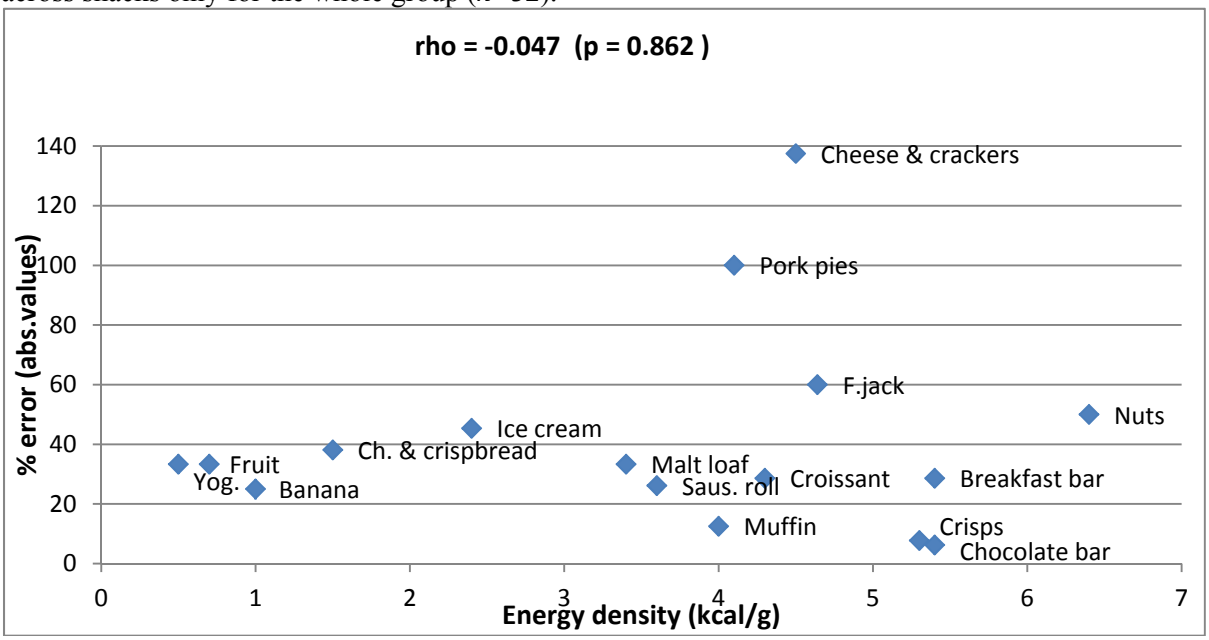


Figure 10b. Energy density and percentage error (absolute values) of mean portion estimates across all non-snack meals and beverages for the whole group (*n*=32).

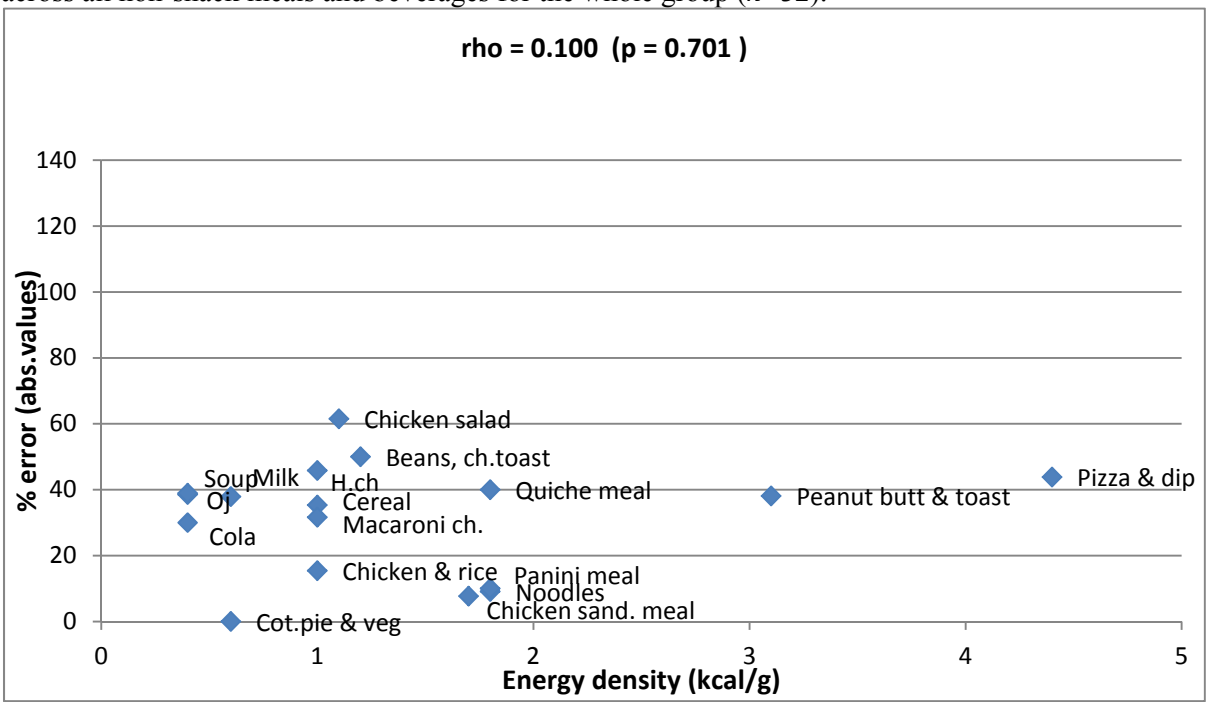


Figure11a. Energy density and percentage error (absolute values) of mean portion estimates across single unit foods only for the whole group (*n*=32).

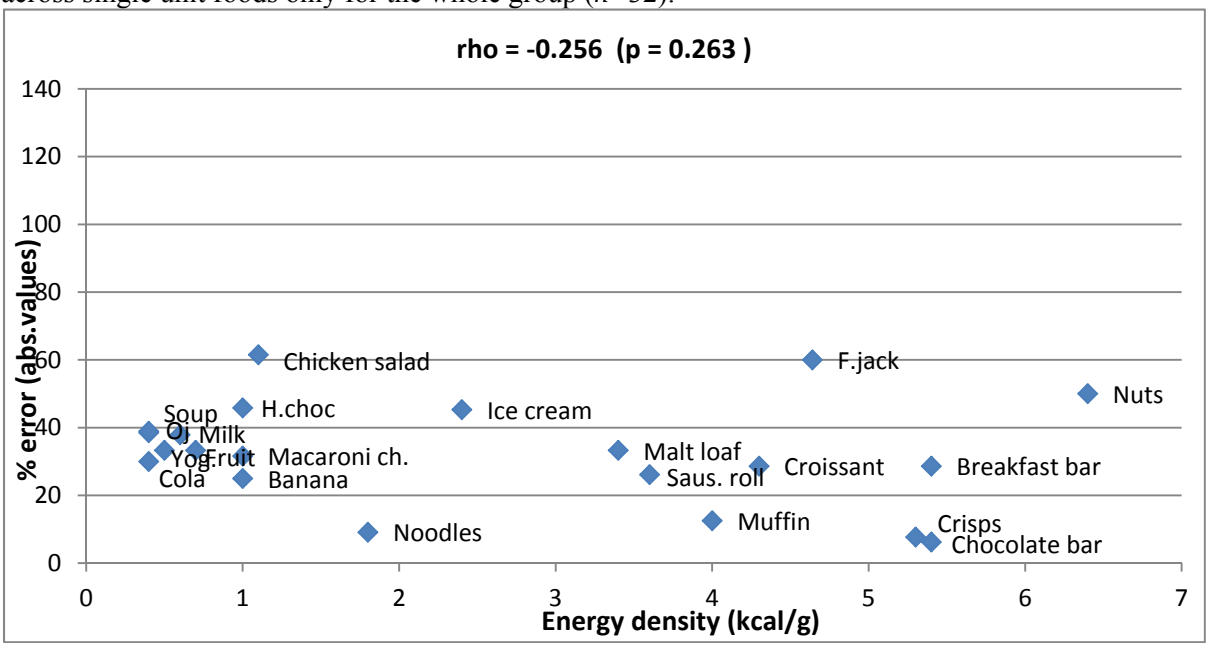
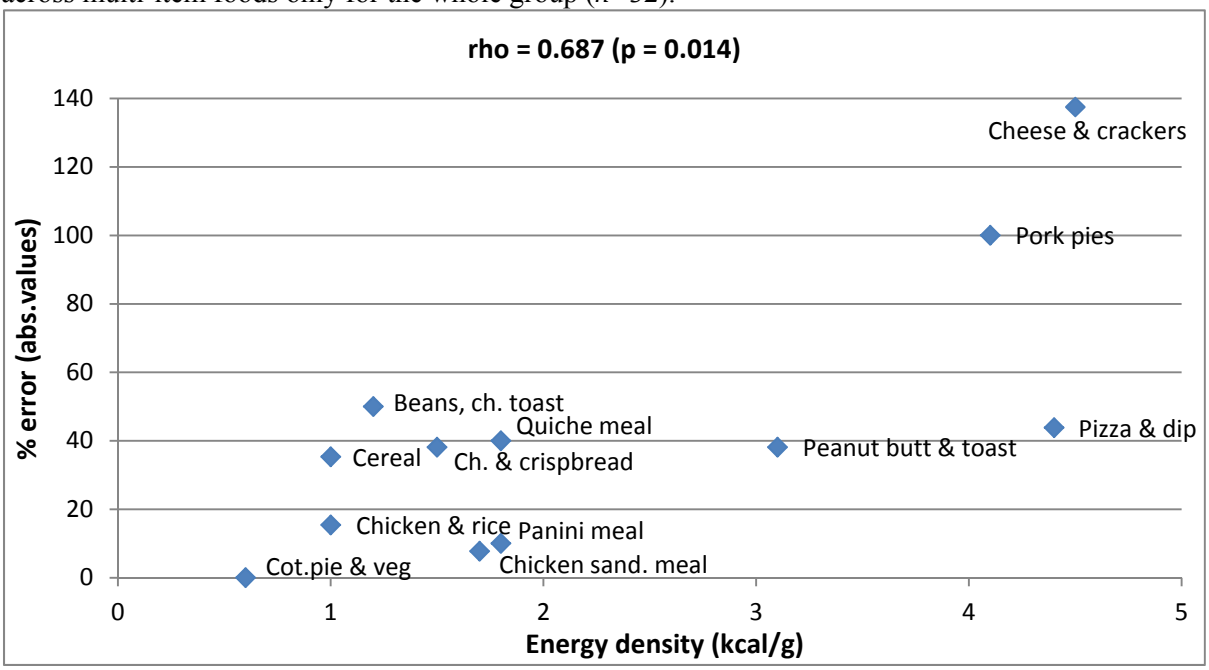


Figure 11b. Energy density and percentage error (absolute values) of mean portion estimates across multi-item foods only for the whole group (*n*=32).



To summarise the results from these graphs **Table 12** shows that it seems to be the actual values that drive the associations between percentage error in estimation and energy density (kcal/g) with the exception of multi-unit food. It appears that in multi-unit foods more error occurs as energy density increases only when using absolute values, as with direction this association is lost.

Table 12. Summary of correlation results between energy density (kcal/g) and percentage error of estimates.
Abbreviations: N/S, non-significant.

	Percentage error (actual)		Percentage error (absolute)	
	Rho		Rho	
All foods	0.404	p = 0.020	N/S	
Snacks	0.546	p = 0.029	N/S	
Non-snacks	N/S		N/S	
Single unit foods	0.576	p = 0.006	N/S	
Multi-unit foods	N/S		0.687	p = 0.014

3.7. Analysis of calorie estimates

3.7.1. Mean VAS scores for calorie estimation

Mean VAS scores for calorie estimation across foods for the whole group and by sex group are shown in **Table 13**.

Table 13. Mean VAS scores (±SEM) for calorie estimation across all foods (n=33) for the whole group (n=32) and by male (n=15) and female (n=17) sex group.

Foods	Mean Group VAS Calories	Mean Female VAS Calories	Mean Male VAS Calories
Carton of fresh orange juice	35.9 (±2.4)	35.9 (±3.4)	35.8 (±3.7)
Pork pies	77.3 (±2.5)	79.4 (±3.6)	74.9(±3.5)
Cheese and crackers	67.1 (±2.7)	65.7(±4.6)	68.8(±2.5)
Cola drink	71.3 (±2.7)	68.2(±4.4)	74.9(±2.5)
Whole milk	61.7 (±3.1)	63.9(±4.4)	59.2(±4.3)
Hot chocolate	70.5 (±2.3)	69.6(±3.8)	71.6(±2.4)
Peanut butter on toast	63.6 (±2.5)	63.7(±4.0)	63.5(±2.9)
Country vegetable soup	32.7 (±2.5)	29.7(±2.1)	36.0(±4.6)
Fruit salad	23.0 (±2.1)	22.7(±2.4)	23.4(±3.6)
Light vanilla yoghurt	25.2 (±2.1)	25.0(±2.5)	25.5(±3.6)
A banana	26.7(±2.3)	27.1(±3.4)	26.2(±3.2)
Croissant	61.6 (±2.9)	61.9(±3.8)	61.3(±4.5)
Chicken salad bowl with a caesar dressing	48.6 (±3.2)	44.8(±4.6)	52.9(±4.5)
Biscuit cereal with semi-skimmed milk	29.7 (±2.3)	31.6(±2.5)	27.6(±4.0)
Instant chicken flavoured noodles	61.4 (±3.2)	60.6(±3.9)	62.2(±5.4)
Flapjack	54.7 (±3.2)	58.4(±4.2)	50.5(±4.7)
Chocolate bar	76.1 (±2.0)	78.1(±3.0)	73.8(±2.5)
Blueberry muffin	66.7 (±2.3)	69.0(±3.3)	64.0(±3.0)
Cereal breakfast bar	43.7 (±3.0)	46.0(±3.6)	41.1(±4.9)
Cottage cheese on crispbreads	41.6 (±3.8)	37.4(±4.7)	46.3(±6.0)
Sausage roll	75.0 (±2.8)	76.8(±4.7)	72.9(±2.6)
Beans and cheese on toast	59.5 (±2.2)	61.2(±3.4)	57.5(±2.8)
Malt loaf	51.4 (±2.8)	50.5(±3.5)	52.4(±4.6)
Crisps	67.2 (±2.5)	69.2(±3.8)	64.9(±3.2)
Peanuts	61.8 (±3.6)	68.1(±4.1)	54.7(±5.8)
Macaroni and cheese	70.7 (±2.3)	72.5(±3.2)	68.7(±3.3)
Chicken in black bean sauce with rice	62.3 (±2.5)	66.5(±2.7)	57.6(±4.0)
Cottage pie with broccoli and carrots	46.1 (±2.4)	46.7(±2.8)	45.5(±4.0)
Ice cream	79.0 (±2.3)	81.9(±3.1)	75.8(±3.2)
Chicken sandwich roll, chocolate bar and a can of cola drink	77.1 (±2.2)	75.9(±3.9)	78.5(±1.8)
Meat and barbeque sauce pizza with a garlic and herb dip	79.2 (±2.2)	81.9(±3.0)	76.2(±3.1)
Cheese & ham quiche and coleslaw	59.5 (±3.0)	58.6(±4.1)	60.4(±4.6)
Bacon and cheese panini, crisps and cranberry juice	71.8 (±2.4)	73.0(±3.4)	70.5(±3.4)

3.7.2. Accuracy of calorie estimation

Spearman's correlations were used to look at the association between mean calorie estimates (VAS) for the whole group (n=32) and actual energy content of the food, as energy density (kcal/g) and total energy load.

Results showed that there was a significant correlation (rho = 0.442, p = 0.010) for the whole group (n=32) between estimated calories (VAS) and energy density (kcal/g), and a significant correlation between estimated calorie (VAS) and total energy load (kcal) (rho = 0.766, p = 0.000) (see **figures 12** and **13**, respectively). This means that subjects were able to estimate calorie content accurately.

Figure 12. Mean estimated VAS calorie content against energy density (kcal/g) across all foods (n=33).

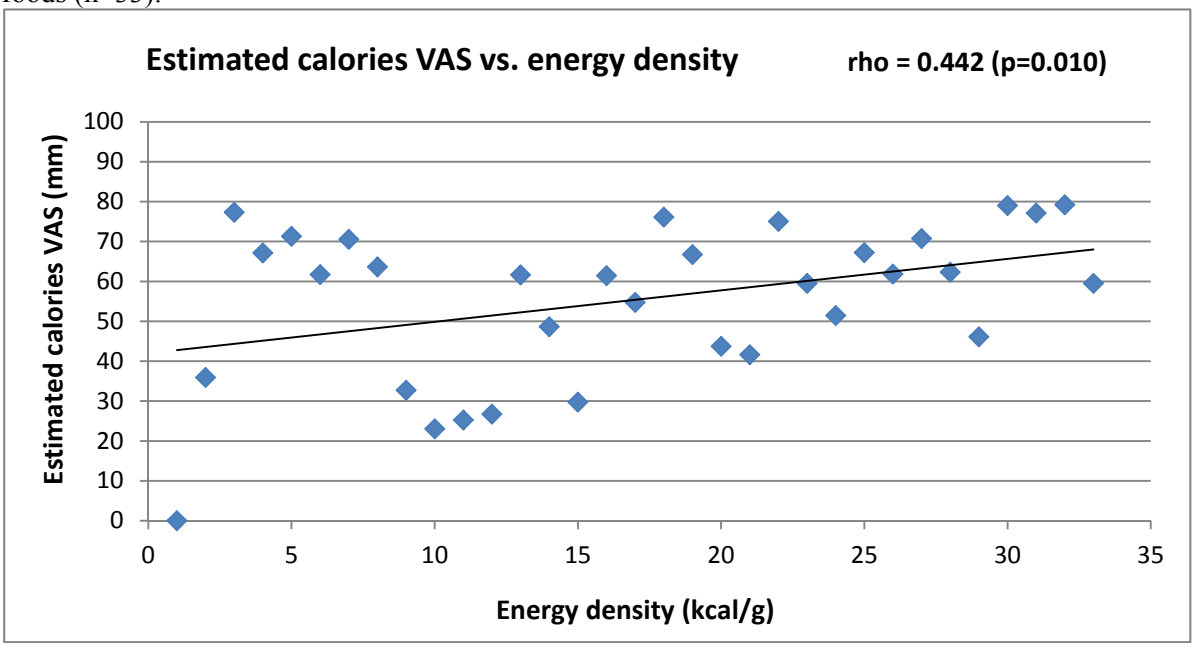
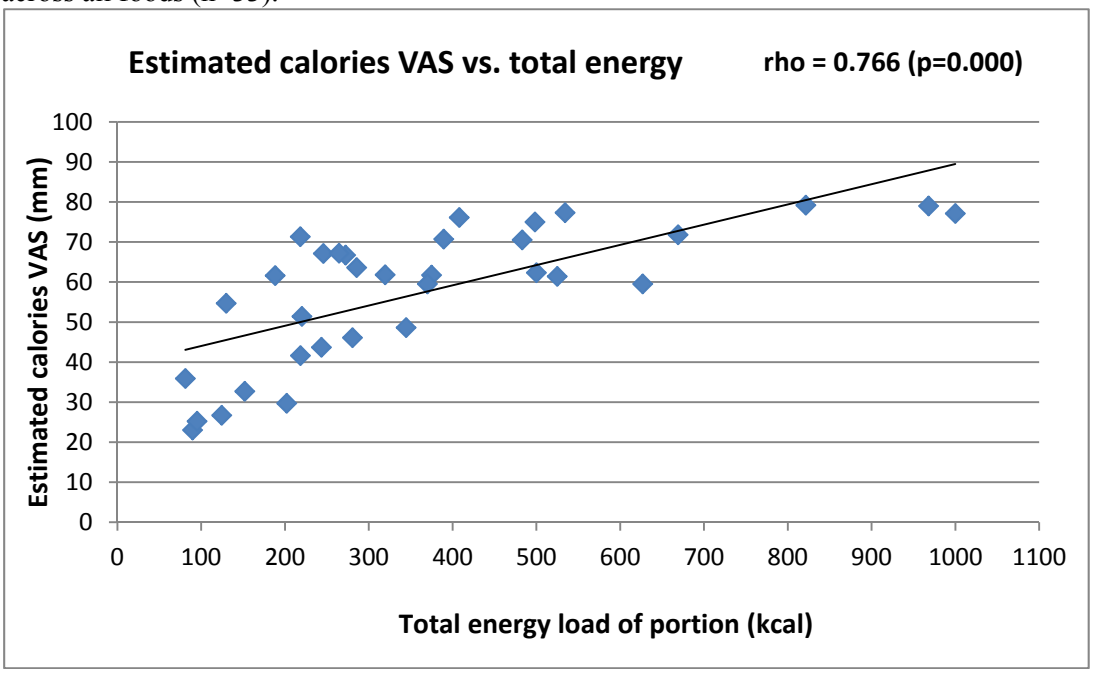


Figure 13. Mean estimated VAS calorie content against total energy load of portion (kcal) across all foods (n=33).



For lower energy dense foods the range of mean estimated calories was much wider for energy density than the range for total energy load. This suggests that the portion sizes of foods for which their calorie content was perceived as high were not underestimated to a larger degree than for foods perceived as low energy content.

3.7.3. Relationship between actual/estimated caloric content and error in estimation

As previous analysed there was a significant correlation (see section 3.6.2) between energy density and actual percentage error of estimation, although no significant difference was seen

(rho = -0.073, p = 0.69) between actual percentage error and total energy load of portion (kcal). Absolute percentage error of estimation was also analysed, results showed that there was no significant correlation between absolute percentage error and both energy density (see section 3.6.2) and total energy load (rho = -0.034, p = 0.85). This means that foods with higher energy density content were associated with more error, although not necessarily the

same direction of error. Meanwhile there no association between the total energy load and the degree of error, whether using the direction of error or not.

The correlation between estimated calories (VAS) and actual percentage error of estimation was analysed using Spearman's correlation for the whole group (n=32). Results showed that there was no significant correlation (rho = 0.094, p = 0.60) between actual percentage error of estimation and estimated calories (VAS). The same results were found when absolute values were used
(rho = -0.048, p = 0.79) This means that the subjects perceived calorie content of foods was not associated with their degree of error when estimating food portion sizes.

3.8. Analysis of fat estimates

3.8.1. Mean VAS scores for fat estimation

Mean VAS scores for fat estimation across foods for the whole group and by sex group are shown in **Table 14**.

Table 14. Mean VAS scores (±SEM) for fat estimation across all foods (n=33) for the whole group (n=32) and by male (n=15) and female (n=17) sex group.

Foods	Mean Group VAS Fat (mm)	Mean Female VAS Fat (mm)	Mean Male VAS Fat (mm)
Carton of fresh orange juice	25.9 (±2.6)	27.9(±3.9)	23.6(±3.4)
Pork pies	80.3(±2.1)	81.6(±3.2)	78.7(±2.7)
Cheese and crackers	67.4(±2.6)	67.3(±4.1)	67.5(±3.3)
Cola drink	56.8(±4.3)	55.8(±5.5)	58.0(±6.9)
Whole milk	73.5(±3.3)	73.9(±5.9)	73.0(±2.7)
Hot chocolate	69.0(±1.9)	69.3(±2.6)	68.5(±2.7)
Peanut butter on toast	63.2(±2.4)	66.2(±3.6)	59.8(±3.2)
Country vegetable soup	25.9(±1.6)	26.7(±2.1)	24.9(±2.4)
Fruit salad	14.0(±1.6)	14.6(±2.0)	13.2(±2.5)
Light vanilla yoghurt	27.9(±3.2)	23.8(±3.4)	32.7(±5.6)
A banana	19.4(±2.4)	20.2(±3.0)	18.5(±3.9)
Croissant	61.4(±3.0)	59.1(±3.8)	64.0(±4.9)
Chicken salad bowl with a caesar dressing	44.5(±3.4)	42.7(±5.0)	46.4(±4.7)
Biscuit cereal with semi-skimmed milk	29.2(±2.3)	32.5(±2.8)	25.5(±3.6)
Instant chicken flavoured noodles	57.9(±3.4)	55.2(±3.9)	61.0(±5.7)
Flapjack	57.0(±2.8)	57.4(±3.5)	56.5(±4.7)
Chocolate bar	76.6(±2.0)	76.8(±3.1)	76.3(±2.5)
Blueberry muffin	62.2(±2.3)	65.8(±3.0)	58.0(±3.4)
Cereal breakfast bar	43.6(±4.1)	51.5(±5.8)	34.7(±5.1)
Cottage cheese on crispbreads	48.1(±4.3)	39.0(±5.1)	58.3(±6.2)
Sausage roll	73.5(±2.8)	76.2(±4.5)	70.4(±2.9)
Beans and cheese on toast	61.3(±1.7)	61.0(±2.8)	61.6(±2.0)
Malt loaf	50.6(±3.2)	50.1(±3.8)	51.2(±5.3)
Crisps	69.9(±1.8)	70.9(±2.7)	68.8(±2.5)
Peanuts	64.5(±3.8)	70.1(±4.5)	58.0(±6.2)
Macaroni and cheese	67.8(±2.4)	69.7(±2.3)	65.7(±4.5)
Chicken in black bean sauce with rice	57.4(±2.9)	60.4(±3.5)	54.1(±4.8)
Cottage pie with broccoli and carrots	40.5(±2.3)	40.9(±3.0)	40.2(±3.5)
Ice cream	78.5(±2.1)	79.4(±3.1)	77.4(±2.8)
Chicken sandwich roll, chocolate bar and a can of cola drink	77.1(±2.1)	77.5(±3.6)	76.7(±1.9)
Meat and barbeque sauce pizza with a garlic and herb dip	79.8(±2.1)	81.4(±2.6)	78.0(±3.4)
Cheese & ham quiche and coleslaw	62.6(±2.7)	62.1(±3.9)	63.1(±3.7)
Bacon and cheese panini, crisps and cranberry juice	69.8(±1.9)	69.6(±3.2)	70.0(±2.1)

3.8.2. Accuracy of fat estimation

Spearman's correlation was used to look at the association between mean estimated fat and actual fat content for both fat density (g/100g) and total fat.

Results showed that there was a significant correlation (rho = 0.633, p = 0.000) for the whole group (n=32) between estimated fat (VAS) and fat density (g/100g), and a significant correlation (rho = 0.866, p = 0.000) between estimated fat (VAS) and total fat content of portion (g) (**figures 14 and 15**, respectively). This means that subjects were able to estimate actual fat content accurately both as fat density and total fat content.

Figure 14. Estimated VAS fat content against fat density (g/100g) across all foods (n=33) for the whole group (n=32).

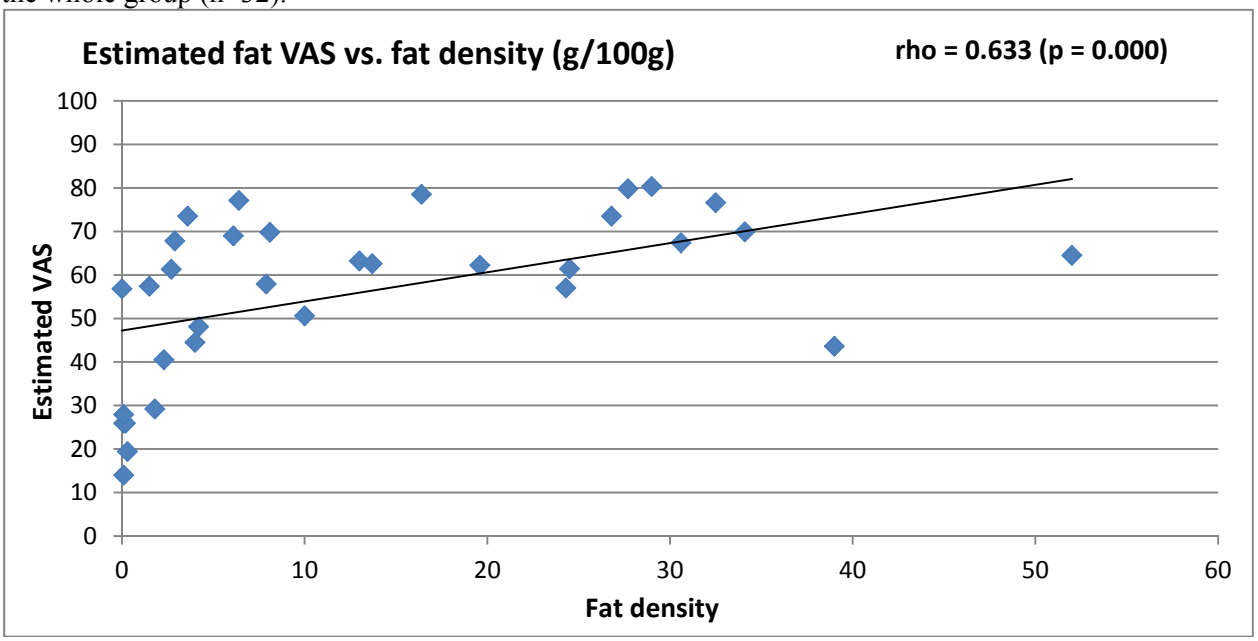
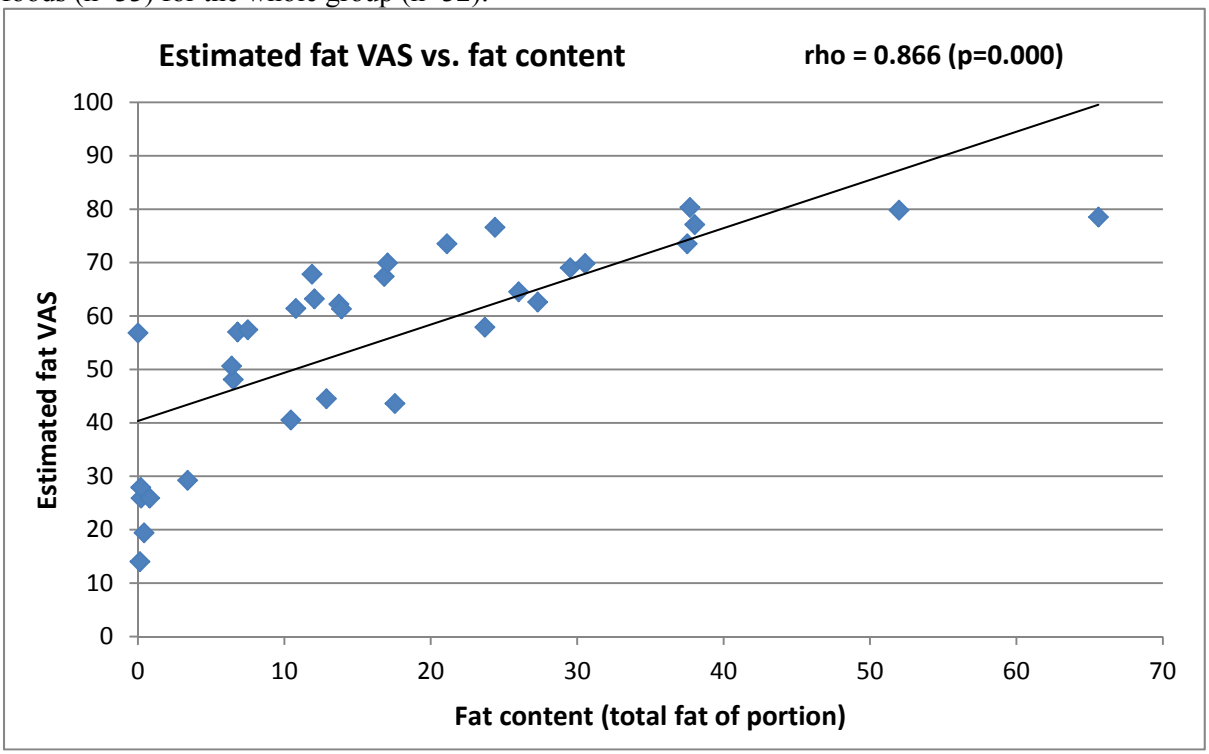


Figure 15. Estimated VAS fat content against fat content (total fat of portion) across all foods (n=33) for the whole group (n=32).



For lower and higher energy dense foods the range for mean estimated fat content was much wider for fat density than the range for total fat content. This suggests that the portion sizes of foods for which their total fat content was perceived as high were not underestimated to a larger degree than for foods perceived as having a low fat density.

3.8.3. Relationship between actual/estimated fat content and error in estimation

The correlation between fat content and actual percentage error of estimation was analysed using Spearman's correlations for the whole group (n=32). Results showed that there was a significant correlation (rho = 0.362, p = 0.038) between actual percentage error and fat density (g/100g), although no significant difference was seen (rho = 0.034, p = 0.85) between actual percentage error and total fat content of portion. Absolute percentage error of estimation was also analysed, results showed that there was no significant correlation between absolute percentage error and both fat density (rho = 0.084, p = 0.64) and total fat content (rho = 0.072, p = 0.69). This means that foods with a higher fat density were

associated with more error, although not necessarily the same direction. Meanwhile there no association between the total fat content and the degree of error, whether using the direction of error or not.

The correlation between estimated fat (VAS) and actual percentage error of estimation was analysed using Spearman's correlation for the whole group (n=32). Results showed that there was no significant correlation (rho = 0.051, p = 0.78) between actual percentage error of estimation and estimated fat (VAS). The same results were found when absolute values were used
(rho = 0.045, p = 0.80) This means that the subjects perceived fat content of foods was not associated with their degree of error when estimating food portion sizes.

Overall we can conclude that neither fat nor calorie content appeared to be related to percentage error of estimation in this sample of subjects.

3.9. Analysis of "usual portion" question and comparison of methods of estimation

3.9.1. Departure (differences) of VAS scores and portion estimates from expected normal portions

To identify the most accurate method in the estimation of portion sizes the usual portion and portion size estimate variables were compared. To compare the usual portion VAS scores with portion estimates a departure (differences) value was calculated from the "expected normal portion". This expected normal portion was defined as a response of 50mm in the "usual portion" VAS question or a response of 1in the "how many portions" question.

The "usual portion" VAS scores were used for the whole group (n=32) and by sex group for each food item to calculate the distance from the centre of the scale (50mm) to

give a positive or negative value, indicating a mean larger or smaller portion, respectively, as their "usual portion" value (**Table 15**).

For a comparable method of estimation, the "how many portions" mean estimates were used for the whole group (n=32) and by sex group for each food item (**table 16**), to calculate its deviation from 1.0 to give a positive or negative value, indicating how much more or less this compares to what they would consume at one occasion, respectively.

Table 15. "Usual portion" mean VAS ratings (±SEM) for the whole group (n=32) and by sex group (males = 15, females = 17) and the departure value (deviation from 50mm) for each group.

Foods	Mean group VAS rating (mm) (±SEM)	Group Departure (mm)	Mean female VAS (mm) (±SEM)	Female departure (mm)	Mean male VAS (mm) (±SEM)	Male Departure (mm)
Carton of fresh orange juice	32.1(±2.4)	-17.9	32.3(±3.0)	-17.7	31.9(±4.0)	-18.1
Pork pies	68.0(±2.6)	18.0	73.0(±3.1)	23.0	62.3(±3.9)	12.3
Cheese and crackers	62.5(±3.4)	12.5	69.5(±4.3)	19.5	54.6(±4.6)	4.6
Cola drink	55.3(±1.7)	5.3	55.7(±2.5)	5.7	54.9(±2.4)	4.9
Whole milk	63.1(±3.5)	13.1	69.7(±5.5)	19.7	55.6(±3.5)	5.6
Hot chocolate	63.1(±2.9)	13.1	68.0(±4.4)	18.0	57.5(±3.3)	7.5
Peanut butter on toast	56.2(±2.9)	6.2	53.6(±3.8)	3.6	59.2(±4.4)	9.2
Country vegetable soup	46.7(±2.3)	-3.3	47.7(±2.8)	-2.3	45.5(±3.9)	-4.5
Fruit salad	39.3(±2.3)	-10.7	39.5(±3.0)	-10.5	39.0(±3.6)	-11.0
Light vanilla yoghurt	51.3(±1.6)	1.3	51.7(±2.5)	1.7	50.9(±1.8)	0.9
A banana	46.8(±1.1)	-3.2	48.4(±1.0)	-1.6	45.0(±2.1)	-5.0
Croissant	41.6(±2.4)	-8.4	41.8(±2.9)	-8.2	41.4(±4.1)	-8.6
Chicken salad bowl with a caesar dressing	69.0(±3.1)	19.0	73.0(±3.9)	23.0	64.5(±4.8)	14.5
Biscuit cereal with semi-skimmed milk	47.8(±2.0)	-2.2	50.0(±2.4)	0.0	45.2(±3.2)	-4.8
Instant chicken flavoured noodles	50.4(±2.4)	0.4	51.2(±1.6)	1.2	49.4(±4.9)	-0.6
Flapjack	25.5(±2.7)	-24.5	30.8(±3.7)	-19.2	19.6(±3.3)	-30.4
Chocolate bar	65.8(±2.4)	15.8	72.3(±2.9)	22.3	58.4(±2.9)	8.4
Blueberry muffin	45.5(±1.8)	-4.5	49.1(±1.9)	-0.9	41.5(±2.9)	-8.5
Cereal breakfast bar	52.3(±2.0)	2.3	57.2(±2.5)	7.2	46.7(±2.7)	-3.3
Cottage cheese on crispbreads	57.0(±2.6)	7.0	58.9(±3.4)	8.9	54.9(±3.9)	4.9
Sausage roll	66.1(±2.8)	16.1	73.1(±3.8)	23.1	58.3(±3.2)	8.3
Beans and cheese on toast	53.6(±3.0)	3.6	59.9(±2.8)	9.9	46.5(±5.0)	-3.5
Malt loaf	48.0(±3.0)	-2.0	52.5(±3.8)	2.5	42.9(±4.4)	-7.1
Crisps	63.2(±2.9)	13.2	66.9(±3.6)	16.9	59.0(±4.5)	9.0
Peanuts	53.7(±4.3)	3.7	62.4(±5.1)	12.4	43.9(±6.5)	-6.1
Macaroni and cheese	53.2(±3.4)	3.2	52.4(±4.7)	2.4	54.0(±5.2)	4.0
Chicken in black bean sauce with rice	50.2(±2.7)	0.2	55.1(±3.0)	5.1	44.6(±4.4)	-5.4
Cottage pie with broccoli and carrots	45.5(±1.9)	-4.5	49.0(±1.6)	-1.0	41.6(±3.4)	-8.4
Ice cream	76.9(±2.8)	26.9	85.4(±2.2)	35.4	67.4(±3.3)	17.4
Chicken sandwich roll, chocolate bar and a can of cola drink	59.6(±2.6)	9.6	64.5(±2.8)	14.5	54.2(±3.3)	4.2
Meat and barbeque sauce pizza with a garlic and herb dip	32.3(±2.5)	-17.7	38.1(±2.8)	-11.9	25.6(±3.6)	-24.4
Cheese & ham quiche and coleslaw	39.2(±3.6)	-10.8	44.9(±5.5)	-5.1	32.7(±4.3)	-17.3
Bacon and cheese panini, crisps and cranberry juice	51.5(±1.7)	1.5	52.9(±2.1)	2.9	49.9(±2.7)	-0.1

Table 16. “How many portions” calculations showing mean estimated number of portions for the whole group (n=32) and by sex group (males = 15, females = 17) and the departure value (deviation from 1 portion) for each group.

Foods	Group Portion Estimate (±SEM)	Group Departue	Female Portion Estimate (±SEM)	Female Departue	Male Portion Estimate (±SEM)	Male Departue
Carton of fresh orange juice	0.8(±0.04)	-0.2	0.8(±0.06)	-0.2	0.8(±0.06)	-0.2
Pork pies	1.8(±0.07)	0.8	1.9(±0.06)	0.9	1.6(±0.12)	0.6
Cheese and crackers	1.9(±0.24)	0.9	2.3(±0.42)	1.3	1.4(±0.13)	0.4
Cola drink	1.4(±0.82)	0.4	1.4(±0.12)	0.4	1.3(±0.11)	0.3
Whole milk	1.8(±0.16)	0.8	2.3(±0.23)	1.3	1.3(±0.12)	0.3
Hot chocolate	1.3(±0.09)	0.3	1.4(±0.13)	0.4	1.2(±0.10)	0.2
Peanut butter on toast	1.3(±0.09)	0.3	1.2(±0.12)	0.2	1.4(±0.14)	0.4
Country vegetable soup	1.1(±0.06)	0.1	1.0(±0.08)	0.0	1.2(±0.08)	0.2
Fruit salad	0.8(±0.04)	-0.2	0.9(±0.05)	-0.1	0.8(±0.06)	-0.2
Light vanilla yoghurt	1.0(±0.02)	0.0	1.0(±0.00)	0.0	1.1(±0.00)	0.1
A banana	1.0(±0.00)	0.0	1.0(±0.00)	0.0	1.0(±0.05)	0.0
Croissant	0.9(±0.03)	-0.1	1.0(±0.03)	0.0	0.9(±0.05)	-0.1
Chicken salad bowl with a caesar dressing	2.1(±0.16)	1.1	2.1(±0.22)	1.1	2.1(±0.24)	1.1
Biscuit cereal with semi-skimmed milk	1.1(±0.05)	0.1	1.1(±0.09)	0.1	1.0(±0.03)	0.0
Instant chicken flavoured noodles	1.2(±0.07)	0.2	1.2(±0.10)	0.2	1.2(±0.12)	0.2
Flapjack	0.8(±0.05)	-0.2	0.8(±0.06)	-0.2	0.7(±0.08)	-0.3
Chocolate bar	1.7(±0.10)	0.7	1.9(±0.11)	0.9	1.4(±0.15)	0.4
Blueberry muffin	0.9(±0.03)	-0.1	1.0(±0.03)	0.0	0.9(±0.05)	-0.1
Cereal breakfast bar	1.0(±0.02)	0.0	1.1(±0.04)	0.1	1.0(±0.00)	0.0
Cottage cheese on crispbreads	1.3(±0.08)	0.3	1.3(±0.11)	0.3	1.2(±0.13)	0.2
Sausage roll	1.7(±0.17)	0.7	2.1(±0.29)	1.1	1.2(±0.11)	0.2
Beans and cheese on toast	1.2(±0.07)	0.2	1.2(±0.10)	0.2	1.1(±0.10)	0.1
Malt loaf	1.2(±0.10)	0.2	1.3(±0.13)	0.3	1.1(±0.16)	0.1
Crisps	1.2(±0.07)	0.2	1.3(±0.09)	0.3	1.2(±0.12)	0.2
Peanuts	1.5(±0.16)	0.5	1.7(±0.25)	0.7	1.1(±0.16)	0.1
Macaroni and cheese	1.3(±0.08)	0.3	1.3(±0.13)	0.3	1.2(±0.11)	0.2
Chicken in black bean sauce with rice	1.1(±0.05)	0.1	1.2(±0.07)	0.2	1.1(±0.07)	0.1
Cottage pie with broccoli and carrots	1.0(±0.03)	0.0	1.0(±0.03)	0.0	0.9(±0.05)	-0.1
Ice cream	2.9(±0.23)	1.9	3.5(±0.32)	2.5	2.2(±0.24)	1.2
Chicken sandwich roll, chocolate bar and a can of cola drink	1.2(±0.08)	0.2	1.3(±0.11)	0.3	1.3(±0.10)	0.3
Meat and barbeque sauce pizza with a garlic and herb dip	0.9(±0.11)	-0.1	0.9(±0.09)	-0.1	0.9(±0.21)	-0.1
Cheese & ham quiche and coleslaw	0.9(±0.09)	-0.1	1.0(±0.14)	0.0	0.9(±0.11)	-0.1
Bacon and cheese panini, crisps and cranberry juice	1.1(±0.04)	0.1	1.1(±0.10)	0.1	1.1(±0.07)	0.1

3.9.2. Departures in each method from expected normal portion across foods

The mean "usual portion" VAS ratings are shown with reference to the FSA portion size reference amount (**Figure 16**) and their departure values from the expected normal portion (**Figure 17**).

The mean portion size estimation ratings are shown with reference to the FSA portion size reference amount (**Figure 18**) and their departure values from the expected normal portion (**Figure 19**).

Figure 16. Usual portion mean VAS ratings (±SEM) for each food item with each label displaying the FSA portion size reference amount. The 50mm line indicates expected normal portion.

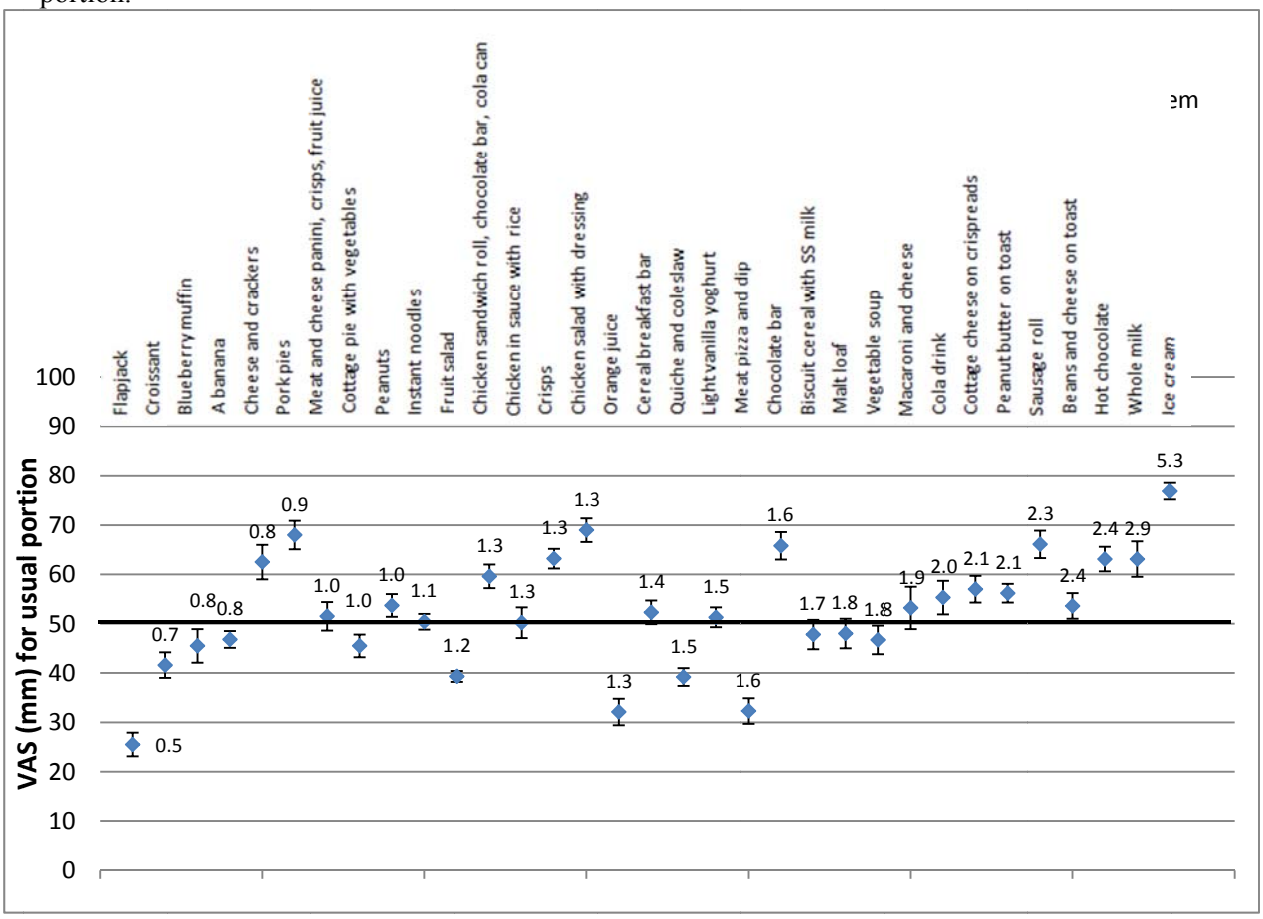


Figure 17. Usual portion mean differences for the whole group (n=32) showing mean difference from the centre of the scale for each food item, the centre (50mm) being classed as the usual portion.

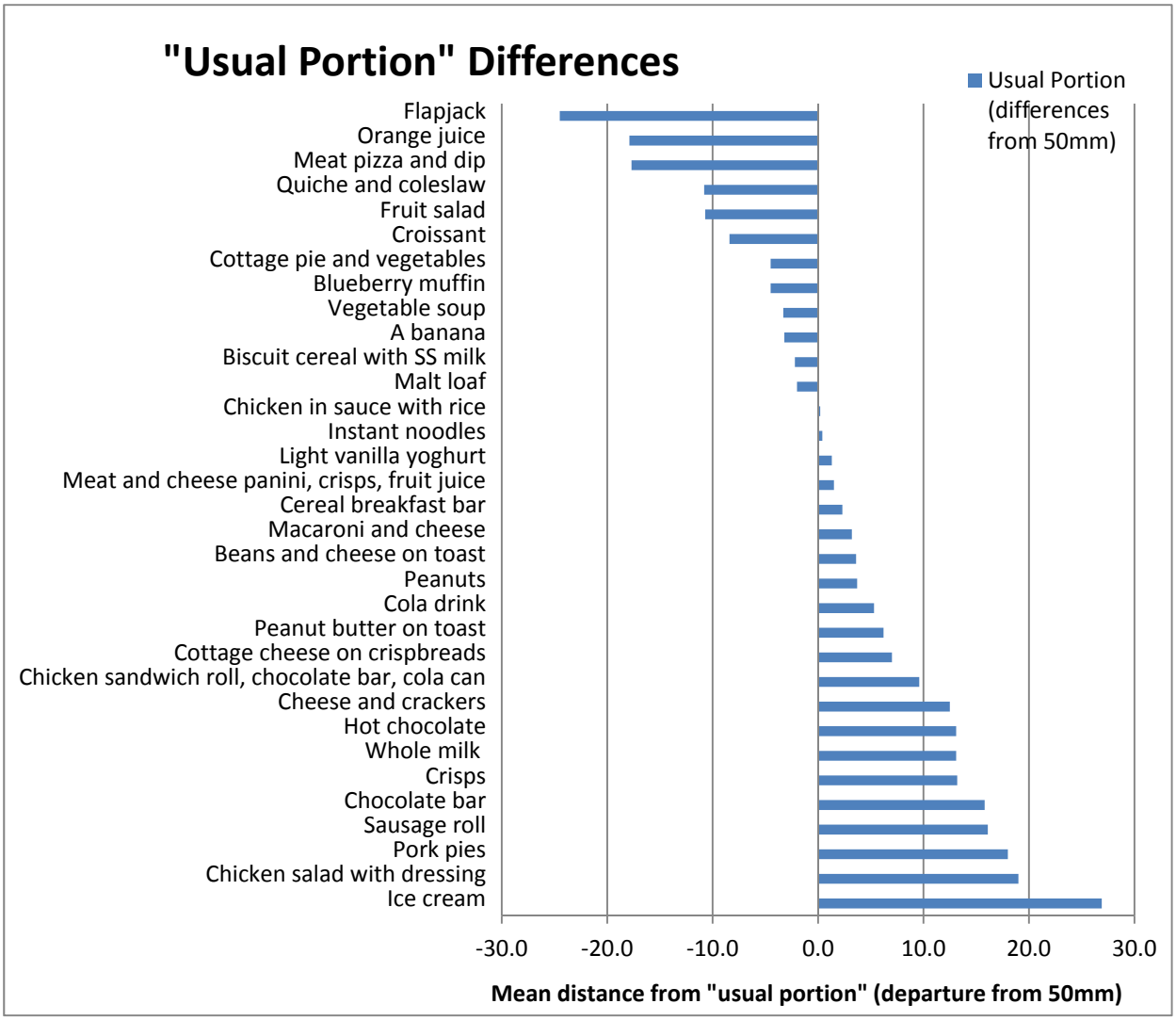


Figure 18. Mean portion size estimates for each food item with each label displaying the FSA portion size reference amount. The 1 portion line indicates a mean estimated portion size of 1.

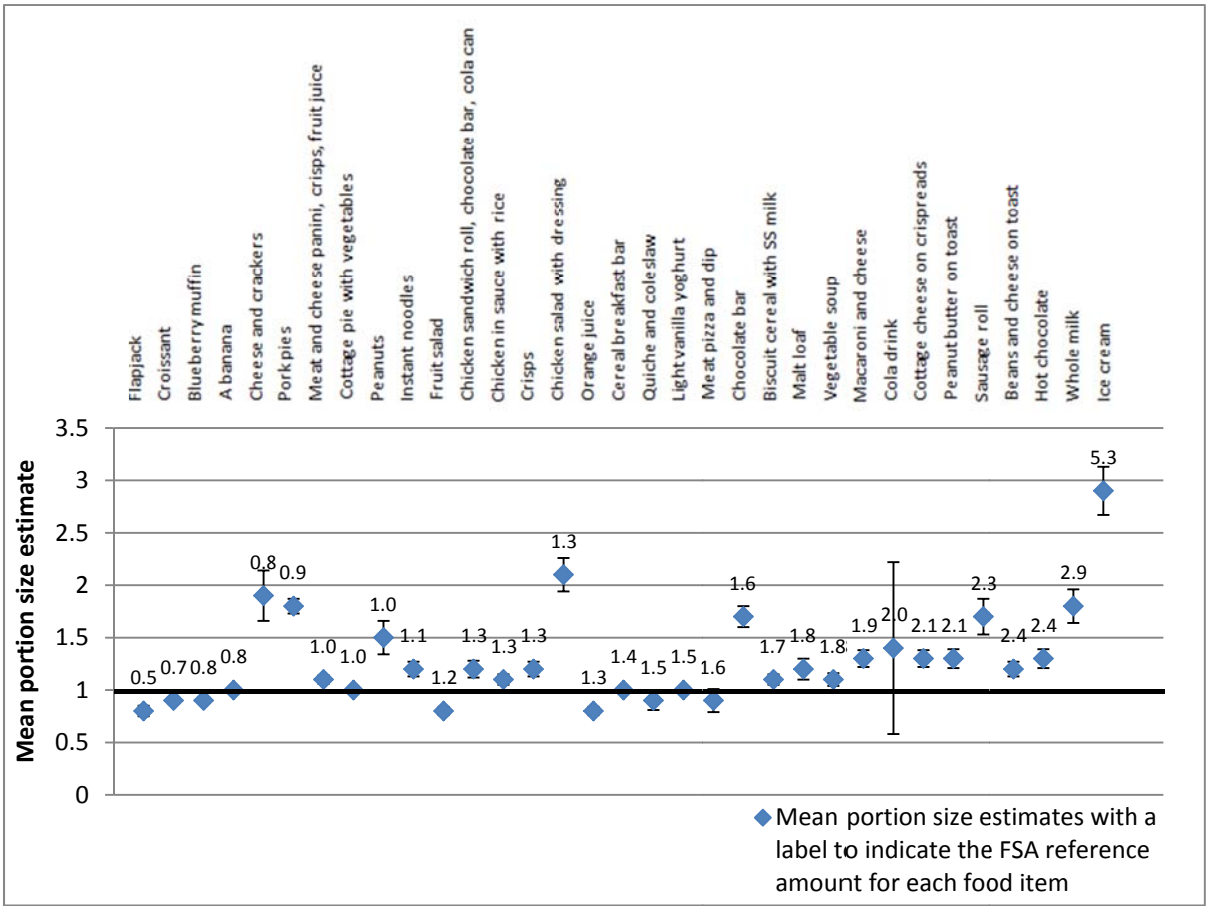
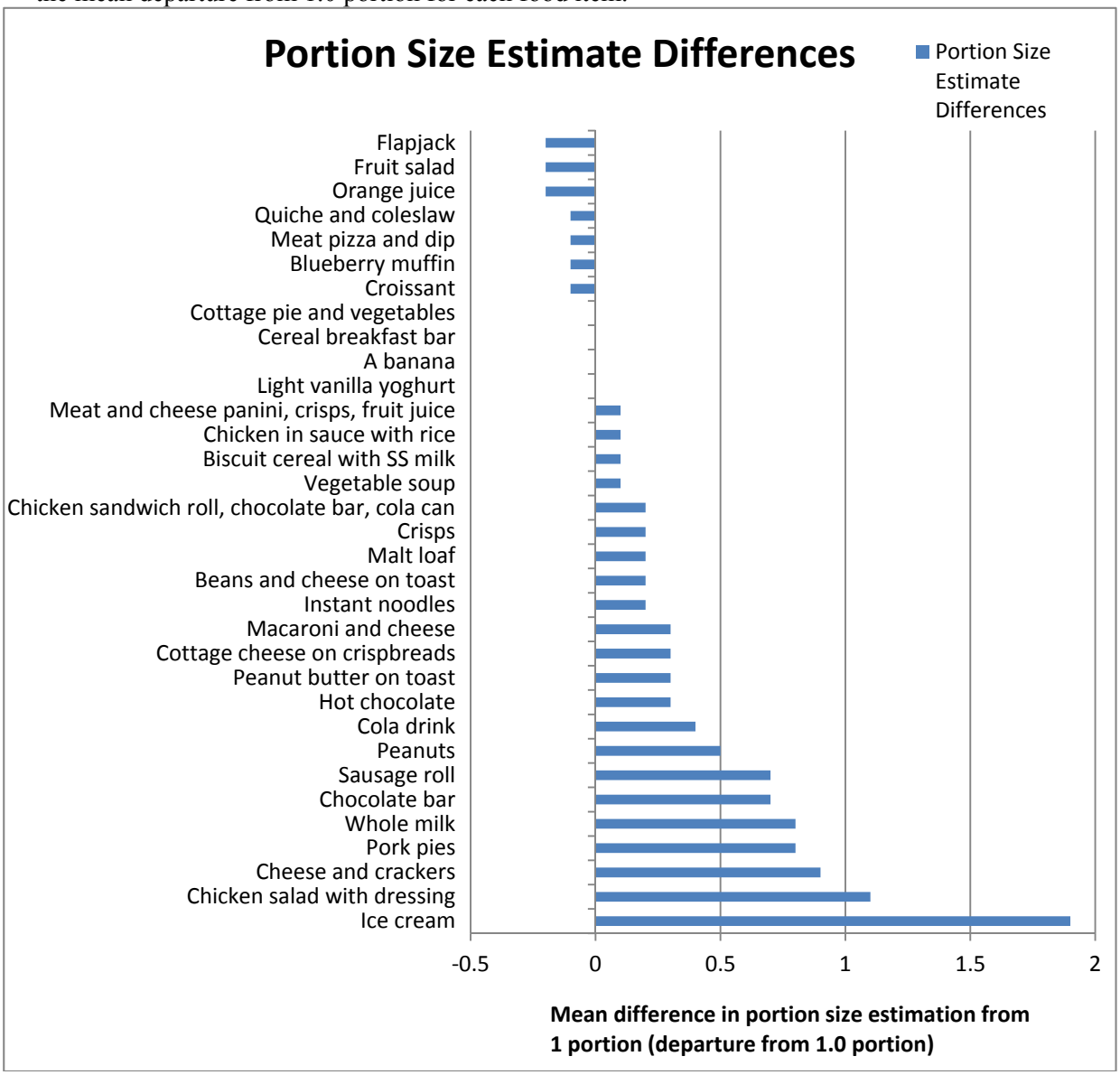


Figure 19. Mean difference in portion size estimation for the whole group (n=32) showing the mean departure from 1.0 portion for each food item.



By comparing both usual portion and portion size estimate means against the FSA reference amount it is visible that subjects could not estimate foods well between 1 – 5 portions, that their responses were inconsistent across foods in terms of direction of error, but mostly that foods were under reported corresponding to >1 reference portion and over reported when corresponding to <1 reference portion.

3.9.3. Departures of VAS scores or portion estimates from expected normal portions

A one-sample t-test was performed to analyse whether the mean usual portion VAS scores for all foods were significantly different from 50. Results of the whole group analysis (n=32) showed that there was no significant difference (p=0.223). By sex group no significant difference was shown in males (n=15, p=0.416) but a significant difference was shown in females (n=17, p=0.010) (**Table 17**). This means that by the whole group and by male sex group the null hypothesis that the VAS scores are not statistically different from 50 can be accepted. By female sex group this null hypothesis is rejected as female VAS scores are statistically different from 50.

Table 17. Usual portion VAS score means, SEM and p-value showing their significance from the test value of 50 for the whole group and by sex group.

Analysis	**Mean**	**SEM**	**Sig.**
Whole group (n=32)	52.5	2.01	p = 0.223
Males (n=15)	48.4	1.89	p = 0.416
Females (n=17)	56.1	2.23	p = 0.010

A Wilcoxon-signed rank test was performed to analyse whether the mean portion size estimates across foods were significantly different from 1. Results of the whole group analysis (n=32) showed significant differences (p=0.000), sex group analysis also showed significant differences in both males (n=15, p=0.000) and females (n=17, p=0.001)(**Table 18**). This means that by the whole group and by sex group the null hypothesis that the mean portion estimates are not statistically different from 1 is rejected.

Table 18. Median portion size estimates, IQR and p-value showing their significance from the test value of 1 for the whole group and by sex group.

Analysis	**Mean**	**IQR**	**Sig.**
Whole group (n=32)	1.2	2.1	p = 0.223
Males (n=15)	1.1	1.5	p = 0.416
Females (n=17)	1.2	2.7	p = 0.010

3.9.4. Departures in each method within food groups

One-sample t-tests were performed to analyse whether the mean usual portion VAS scores were significantly different from 50 within each sub-group (e.g. snacks, non-snack meals and beverages, single-unit foods or multi-item foods). Results of the whole group analysis (n=32) showed that none of the means for any sub-group significantly differed from 50 (**Table 19**).

Table 19. Usual portion means, SEM and p-value showing their significance from the test value of 50 for the whole group (n=32) by sub-groups.

Sub-group (n)	**Mean**	**SEM**	**Sig.**
Snacks (n=16)	54.0	3.24	p = 0.240
Non-snack meals and beverages (n=17)	51.1	2.47	p = 0.660
Single-unit foods (n=21)	52.8	2.74	p = 0.318
Multi-item meals (n=12)	52.0	2.87	p = 0.510

A Wilcoxon-signed rank test was performed to analyse whether the mean portion size estimates were significantly different from 1within each sub-group. Results of the whole group analysis (n=32) showed that the portion estimates were significantly different from 1 in all sub-groups (**Table 20**). This table highlights that the way subjects estimated the foods displayed corresponded to 0.2-0.4 above 1, i.e. they believed the foods displayed to be 20-40% more than the amount they would normally as one portion.

Table 20. Portion estimate means, SEM and p-value showing their significance from the test value of 1 for the whole group (n=32) by sub-groups.

Sub-group (n)	**Mean**	**SEM**	**Sig.**
Snacks (n=16)	1.4	0.14	p = 0.019
Non-snack meals and beverages (n=17)	1.2	0.08	p = 0.003
Single-unit foods (n=21)	1.3	0.11	p = 0.006
Multi-item meals (n=12)	1.2	0.09	p = 0.007

While significant differences were found between portion estimates for each sub-group and 1, the departure in differences between groups (e.g. Snacks vs. Non-snack meals and beverages and single-unit foods vs. multi-item meals) were not significantly different as previously presented in section 3.4.2 and summarised in **Table 21**. Once again this suggests that both the presentation of foods and food labelling had no affect on how far subjects found the portions to be from their normal consumption but this would need further confirmation using an intervention study.

Table 21. Portion estimate departure means, SEM and p-value showing the significance in departure means for the whole group (n=32) between food groups.

Sub-group (n)	**Departure mean**	**SEM**	**Sig.**
Snacks (n=16)	0.4	0.14	p = 0.571
Non-snack meals and beverages (n=17)	0.2	0.08	
Single-unit foods (n=21)	0.3	0.11	p = 0.593
Multi-item meals (n=12)	0.2	0.09	

Chapter 4. DISCUSSION.

4.1. Summary of results

In this sample of subjects there were no differences in baseline appetite or thirst ratings across study sessions ($p>0.05$ for all measures). The median portion estimate was 1.2 (0.8-2.9); estimates were lower in males than females for 6 foods ($p<0.08$) but did not differ across categories for food type or unit size. Participants underestimated 19 foods that were presented as >1 reference amount; whilst overestimating 9 foods presented as ≤ 1 reference amount when analysed by mean values for all subjects[2]. Non-snack foods and beverages were estimated with larger variability than snacks but the magnitude of absolute error was the same across food categories. Percentage error of estimation changed from <0 to >0 with increasing energy density in all foods and within snack (n =16) and unit food (n=21) categories only. This was associated with portion sizes of high energy density foods being overestimated versus all other foods being underestimated ($p<0.05$). Absolute percentage error of estimation correlated with energy density in multi-item foods but not in any other food category or in the whole sample. Portion sizes of multi-item foods were also estimated with increasing error as energy density increased, however, included both over and under-estimations. Subjects estimated fat (rho=0.89) and calorie (rho=0.77) content correctly and this was not associated with the changes in error of estimations observed. Participants found most of the portions displayed close to a usual portion for that food, whilst their median portion estimates were above 1 in all food categories ($p<0.05$ for snacks and $p<0.001$ for all others).

4.2. The effects of food types and food units on portion size estimates

Results showed that portion estimates in females were on average higher than in males, specifically in high and medium energy dense snacks (with the exception of one very-

[2] Using individual data we detected some effects of both label and unit size, this will be further explored in a publication arising from this study.

low energy dense beverage). This opposes the findings of Burger et al (2007) who found that females rated portions of high energy dense foods as smaller compared to males, whilst generally supporting their finding for low energy dense foods where they observed no difference in portion estimates between sex groups. This suggests that both men and women have a similar perception of what constitutes a 'portion' for low energy dense foods, but likely a different perception of high energy dense foods.

The cognitive representations of foods have been shown to moderate food choices in the short-term. For example, when subjects were asked for their perception on whether presented foods are typically consumed as a meal or a snack, consumption was increased more for foods perceived as snacks than meals (Capaldi, Owens & Privitera, 2006). Our study found that the labelling of foods by food type (e.g. as a meal, snack or beverage) had no effect on portion size estimation in this sample of subjects. In light of this, coupled with the fact that increasing portion sizes of foods increases energy intake (Kral et al, 2004), we could suggest that an individual's learned beliefs drives their perception of food type and influences food choice, with food labelling having a minimal effect on this perception. However, one must be cautious when using average values, as this may not be sensitive enough to detect individual variability such as differences in perception and behaviour as outlined by Capaldi (1996).

Unit size also had no effect on estimated portion size in this sample of subjects. This suggests that the presence of multiple units is not a main factor influencing an individual's perception of an appropriate portion size. One explanation for this is that cognitive factors play a more relevant role and that individual's may estimate portion sizes on the basis that their culturally accepted portion sizes are used as reference standards irrespective of unit size.

A significant difference in percentage error of estimates was only evident between snack and non-snack meals and beverages when using actual percentage error values, with this difference mainly being driven by females. This effect disappeared when using absolute values highlighting that it is the direction of error (over or underestimation) that is driving

this difference and not the amount of error between food types. There were no differences across unit size categories when using either type of percentage error, therefore the secondary hypothesis (portion size of individual food items will be estimated more accurately than portion size of multi-food items, irrespective of energy density levels in both males and females) could not be demonstrated. This suggests that neither food type nor food unit appears to play a significant role in the estimation of portion sizes. However, the average values collected across the 32 subject could have masked the effect of meal type and unit size between individuals, therefore one must be cautious when interpreting these results. A full individual dataset analysis carried out after this work was able to detect these differences.

4.3. Accuracy of portion size estimation vs. portion size reference amounts

When comparing estimated portion size of all the test foods/drinks to the FSA reference amounts, the majority of foods corresponding to more than 1 reference portion were underestimated, whilst the majority of those less than or equal to 1 reference portion were overestimated. Therefore, subjects' ability to correctly estimate portions above and below reference amounts was weak. With the increased availability of a range of portion sizes in the UK over the last 15-20 years (Church, 2008) and an increased exposure to larger portion sizes out of the home (Young & Nestle, 1995), this underestimation seen on larger portion sizes may therefore be due the phenomenon known as portion distortion. Portion distortion refers to when larger portion sizes are thought to be an "appropriate amount to eat at a single eating occasion" (Schwartz & Byrd-Bredbenner, 2006a) and thus lead to increased energy intake (Steenhuis & Vermeer, 2009). With both underestimation and overestimation being observed it appears that individuals struggle to evaluate amounts > or <1. A factor to consider for this is that the FSA reference amounts have certain limitations, originally published in 1990 based on UK portion sizes customarily consumed in 1986/7, only with some changes for the 2002 edition (Church, 2008), these guidelines may no longer

be a true reflection of portion sizes in 2012. From our results it appears that Another factor which may have influenced portion size estimation was that some foods were displayed as a single unit, which may have lead to individuals believing the unit foods presented were one portion, a perception known as 'unit bias'. This suggestion is in support of research by Geier et al., (2006) who argue that one single unit is the appropriate amount to consider as a portion within an appropriate range of sizes. We can therefore assume that one unit tends to act as a magnet pulling foods presented within an acceptable range or "magnetic field" towards being perceived as one unit, regardless of whether they are more or less than one reference portion.

4.4. The effects of energy density on percentage error of estimates

Actual percentage error of estimates was affected by energy density category for this group of subjects as error changed from <0 to >0 as energy density increased in all foods. This result supports part of the primary hypothesis (there will be a positive correlation between the foods energy density and decreased accuracy of estimation measured as percentage error in portion estimates when compared to reference amounts). Categorically, high energy dense foods were overestimated, whilst all other energy densities were underestimated. Recent findings have shown that the energy density of foods is the best predictor of expected satiety (expectations relating to the absence of hunger after a meal) (Brunstrom et al., 2008) and thus portion selection (Brunstrom & Rogers, 2009). From this it has been hypothesised that energy dense foods tend to occupy smaller volumes (kcal/mm^3), have a lower expected satiety (Brunstrom, Collingwood & Rogers, 2010) . However, from our findings it can be assumed that the subjects may have perceieved these foods as high in energy and fat and so you would need less of them to make you feel full, thus they overestimate.

Absolute percentage error correlated with energy density in multi-item foods but not in any other food category nor in the whole sample. The size of portions presented for multi-item foods were estimated with increasing error as energy density increased. These results support the secondary hypothesis (portion sizes of multi-item foods of a high ED will be estimated less accurately than portion sizes of multi-item foods of a medium or low ED in both males and females) and would further support Brumstrom et al (2010) hypothesis on the effects of volume. In a recent study on multiple foods items Keenan et al (n.d.) found that when food variability increased, subjects judged their expected satiation on perceived volume. In this study, it can therefore be assumed that perceieved volume played a role in the estimation of portion sizes in multi-item foods with subjects poorly estimating high energy dense foods due having a smaller physical volume and therefore expected satiety. In addition to this, people may have experienced difficulty when gauging sizes of meals made up of various items.

4.4.1. The effects of energy density by food type and food unit on percentage error of estimates

Associations were evident between actual percentage error of estimates and energy density by food type and food unit. Labelling foods as a "snack" and displaying foods as single units led to increased error with increasing energy density, whilst labelling foods as "meals" or "beverages" and displaying foods as multi-item did not. However, the absolute correlations are key as with actual percentage error values a positive correlation is shown between energy density and error in foods categorised as a snack and single unit. This correlation is only driven by overestimation of high energy dense foods whilst lower energy densities are underestimated. Therefore, when direction of error is omitted, the significant relationship between error and energy density is lost for "snack" and single unit foods, for this reason overall error in estimation is not associated with energy density. Our study found that in multi-unit foods more error occurred as energy density increased when using absolute

values. These findings are in-line with Kral (2006) who hypothesised that "the correct identification of portion size changes may be facilitated when single foods are served compared to when combination foods are served" and this may partially be due to participants judging single foods more accurately by drawing on prior experience as opposed to perceived volume (Keenan et al., n.d.).

4.5. Accuracy of calorie estimates and actual caloric content and their effects on percentage error of estimates

In a study by Rolls et al (2007) participants were served meals of a standard portion size, after a two week washout period all portion sizes of the same meals were increased by 50%. Despite participants having some awareness of portion manipulation between the two test days they did not however report any change in perceived calorie content and they ate more in the 50%+ condition. In the present study subjects were able to accurately estimate calorie content in terms of energy density and total energy. This may suggest that despite participants being able to correctly identify the calorie content of foods (including snacks, meals and beverages), they may be unable to judge the effect an increase in portion size has on calorie content. Studies employing different methods to assess perceived calorie content, by asking participants to note down their estimated calorie content found calorie estimates were often inaccurate. For example, a study by Schwartz & Byrd-Bredbenner (2006b) observed that when young adults were asked to estimate the calories in self-served meals, one third of the calorie estimates were underestimated by 26% or more, whilst only one fifth of estimates were within a 25% margin of their actual calorie content. Geier & Rozin (2009), on the other hand displayed a small and large portion of the same meal, and observed an overestimation in both meals of approximately 73% and 6%, respectively. With the large meal being closer in size to a standard meal, this further suggests that a change in portion size whether increased, or in this case decreased, has a minimal effect on estimated calorie content.

Despite subjects accurately estimating the calorie content of foods, there was no association between the perceived calorie content of foods and the degree of error when estimating portion sizes. This suggests that perceived calorie content may not play a significant role in the estimation of portion sizes.

4.6. Accuracy of fat estimates and actual fat content and their effects on percentage error of estimates

In relation to calories, subjects were able to accurately estimate fat content in terms of fat density and total fat in our present study. Whereas Rolls et al. (2007) found that participants in their study did not report any change in perceived fat content despite an increase in portion size. Again the results from these two studies suggest participants may be unable to judge the effect a change in portion size has on fat content, further contributing towards the need to assess the sensitivity of the VAS scale in detecting both perceived calorie and fat content between varying portion sizes. Similarly to calorie content, despite subjects accurately estimating the fat content of foods, there was no association between the perceived fat content and the degree of error when estimating portion sizes. Participants' apparent low sensitivity to fat content in terms of estimating portion size also supports the findings by Rolls et al. (2007) that participants rating of fat content in foods, snacks and caloric beverages did not differ between conditions despite a 50% increase in portion sizes. However, a positive association between foods with a high fat density and subjects percentage error of estimation seen in this study suggests that individuals' may find it more difficult to estimate foods of a high fat density compared to those with a lower fat density.

4.7. The effects of comparable portion size estimation methods on expected normal portions

Previously the "usual portion" question has been successfully used to compare portion size ratings against an individuals' usual portion (Rolls, Roe & Meengs, 2004c; Kral et al., 2004; Rolls et al., 2007). However, contrasting results (Kral, Meengs, Wall, Roe & Rolls, 2003) whereby subjects were unable to identify a change in portion size (100%, 150% and 200%) in relation to their usual portion have lead to Kral (2006) to query the accuracy of the "usual portion" question in estimating an individual's habitual portion size in different types of foods. It is important to note that this query is based on the fact that the results of Kral et al. study (2003) are based on subjects rating the portion sizes of combination foods, as opposed to single foods which the results from the previous studies are based on.

We found that our mean usual portion results did not differ from subjects "expected normal portion" (defined as a response of 50mm in the "usual portion" VAS question) for any sub-group, thus we can assume that the accuracy of this usual portion question is consistent across all sub-categories, including multi-item meals. Our findings therefore do not support the theory by Kral (2006) regarding the inaccuracy of the "usual portion" question across different types of foods, these findings did however highlight that neither, the presentation of, or labelling of foods affected how far subjects found the portions to be from their normal consumption. However, when the "usual portion" method was compared to subjects mean portion size estimates, results from our study show that portion estimates were significantly different from 1 portion in all sub-groups. This indicates that the portion size estimate question was better at detecting departure from "1" (habitual) portion than the usual portion question. Therefore, further to Kral's (2006) concerns we can suggest that the "usual portion" question may not be the most accurate method in estimating an individual's habitual portion size across all food types.

On an individual basis, 12 foods were underestimated, 2 were equal to and 19 were overestimated in comparison to their usual portion. This not only gives strength to our

previous findings that larger portions were underestimated, but also supports the notion that portion size estimation is based on the amount habitually consumed (Brunstrom & Shakeshaft, 2009; Brogden & Almiron-Roig, 2011). More specifically, habituation to a smaller or larger portion than the reference amount may have a stronger impact on estimation than unit size, label and energy density due to their usual portion acting as their culturally designated portion size. Finally, other studies looking into the role that expected fullness (expected satiation) has on portion size estimation found when subjects perceived foods to be more filling they rated them as larger than those thought to be less filling (Brogden & Almiron-Roig, 2011). This suggests that the variation in portion size estimates observed in this study may have been influenced by participants past experiences in term of expected satiety, this would indicate that the 19 food/drink items overestimated (e.g. ice-cream, pork pies) were perceived as more filling than the 12 food/drink items that were underestimated (e.g. flapjack, orange juice).

4.8. Limitations of this work and future research

This study found that neither the labelling of foods by food type or the displaying of foods by unit type had an effect on estimated portion size when analysed by average estimates across the 32 subjects. However, limitations may arise from the statistical analyses of the data set, as means and median analyses are unable to detect specific interactions and may mask certain results. Therefore, a full dataset analysis represented beyond the scope of this dissertation is going to be considered in the publication arising from this work. In addition, this study was not an intervention but an observational study meaning we did not change the "label", "unit size" or energy density of the foods, we merely classified them and observed if there were any differences between groups. It would be interesting to further analyse portion size estimation by conducting a study where either food unit or packaging type is the variable to see the effect multiple units have on portion estimations or the effect packaging has depending on the packaged foods perceived form. It is also important to note that the sample of this study were relatively young, with a lean BMI. Therefore, results can not be generalised to the wider population including those who are overweight or those older than our sample.

Further work could be carried out to look at the degree to which visual external influences such as labelling or food type has on portion size estimation compared to internal cognitive (cultural based) beliefs, and based on these learnt beliefs and how participants perception of the same foods vary between food types e.g. whether they are perceived as a snack or meal.

In terms of portion size estimation, reduced sample size for sub-groups could have decreased power. It is important to note that there were only 10 foods in the high energy dense category and our result could have been influenced by the foods that were chosen, therefore to strengthen our findings we would need to repeat with a greater number of high energy dense foods.

Details regarding menstrual cycles were not ascertained on test days and despite evidence that menstrual cycle affects appetite (Brennan et al., 2009) no significant differences in levels of hunger, fullness or thirst were detected in females between test days. This suggests that stages in menstrual cycle and therefore appetite were counterbalanced as all 17 females came at different times during their cycle. In addition to this, a snack was provided to further standardise appetite levels. Furthermore, with no test food items being consumed, participant's estimations would not have been affected by financial factors, as it has been suggested that when food is perceived as free and is prepared ready for consumption larger estimations may occur (Burger et al., 2007). If this was the case then it can be assumed that all foods and energy densities may have been overestimated to the same degree, therefore the range between two comparable elements would remain the same.

Finally, the containers food and drink items were presented in varied across test foods. The appearance of a container or package from which food was estimated, otherwise referred to as 'platescape' or 'packagescape' can define norms in terms of the amount of food or drink to consume (Sobal & Wansink, 2007). The extent of this effect was observed by Wansink & Van Ittersum (as cited by Sobal & Wansink, 2007) when participants served themselves increasing amounts of breakfast cereal as bowl capacity size increased (12oz, 16oz & 24oz) in order to maintain a relatively constant fill level (77%, 74% & 64%, respectively); and Marchiori et al. (2012) who found that when container size was increased by 300%, calorie intake of M&M's was more than doubled. Therefore, estimates of portion size, fat, calories and comparisons to 'usual' portion may have been influenced by the container or package in which food items were displayed.

How accurate participants' answers are to the 'usual portion' question in the laboratory setting in comparison to their usual portion in their natural environment is questionable.

4.9. Implications for professional practice

This study demonstrates how subjects' ability to correctly estimate portions above and below reference amount was weak, with the majority of foods corresponding to more than 1 reference portion being underestimated. This underestimation along with the fact that portion sizes have increased over the last 20 years by 200-500% (Young & Nestle, 2003) may lead to portion distortion, overconsumption and weight gain (Schwartz and Byrd-Bredbenner, 2006a). This indicates that current guidance schemes may not be representative of habitual portions consumed for popular foods and may be difficult to integrate in nutrition education programmes. Therefore, re-education on what constitutes as an appropriate portion sizes is necessarily. Estimation may have been influenced to some extent by energy density as categorically, portions were estimated (over and under reference amounts) across food groups with a significant increase in error of estimation for multi-item foods only. As portion reference amounts were not available for some of the multi-item foods displayed, calculations were made based on their individual components. This, apropos the effect of energy density on multi-item foods, suggests that guidance schemes must incorporate information regarding suitable portion sizes of multi-item foods, especially of those high in energy density. It order for the implementation of these guidelines to be successful in preventing weight gain, portion sizes available in supermarkets and restaurants should be encouraged to incorporate such guidelines, and in doing so may go on to reduce the effect of portion distortion. With our results also indicating that neither, the labelling of foods by food type or displaying of foods by food unit had an effect on portion estimates, this may suggest that cognitive skills are required in portion size estimations. This highlights the need for an appropriate portion size reference tool especially for individuals preparing or self-serving foods who are trying to maintain or lose weight.

CONCLUSIONS.

The main findings of this study are summarised below:

- In a sample of 32 healthy men and women (15 males and 17 females), aged 19 - 44 years, portion size estimates of 33 foods/drink were overestimated for portions corresponding to ≤1 reference amount (9 foods) and underestimated for portions >1 reference amount (19 foods).
- Percentage error of estimation was not influenced by unit size or meal classification, and was not associated with energy density in the whole food sample, nor in snacks, meals/beverages or single foods, but correlated positively with energy density in multi-items foods.
- Meal type and unit size did not influence portion estimation.
- The portion size of multi-item foods was estimated with increasing error as energy density increased but included both over and under-estimations.
- Subjects estimated the fat and calorie content correctly and this was not associated with changes in error of estimation.
- Participants found most of the portions displayed close to a usual portion for food, yet median portion estimates were above 1 in all food categories.
- To help prevent the selection or service and therefore, overconsumption of large portion sizes outside of the home (especially multi-item foods of high energy density), the development of an appropriate guidance scheme and its implementation by supermarkets and restaurants is vital.
- To help prevent the self-serving of large portion sizes inside the home an appropriate portion size reference tool would be beneficial to individuals trying to maintain or lose weight.

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Appendices

Appendix 1a: VAS Questionnaire on hunger, fullness and thirst

Visual Analogue Scale (VAS) Questionnaire Appetite and Alertness

Condition _____ Time _____

Date _____ Subject ID number_____

Instructions for Use

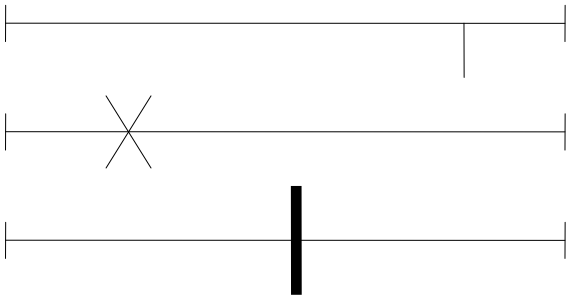
1) Please read the question above each VAS scale carefully.

2) Place a vertical line across the scale in a position which reflects your response most accurately

3) Look at the examples overleaf to help you.

Mark the line like this:

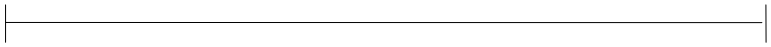
But **NOT** like this:



Scales will be 100 cm in length

How full do you feel? The scale ranges from ‘not full at all’ to ‘extremely full’.

Not full at all Extremely full

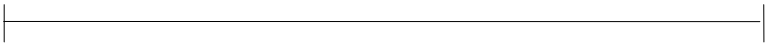


How alert do you feel? The scale ranges from ‘not alert at all’ to ‘extremely alert’.

Not alert at all Extremely alert

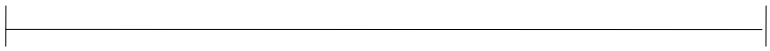
How hungry do you feel? The scale ranges from ‘not hungry at all’ to ‘extremely hungry’.

Not hungry at all Extremely hungry



How tired do you feel? The scale ranges from ‘not tired at all’ to ‘extremely tired’.

Not tired at all Extremely tired



How sleepy do you feel? The scale ranges from ‘not sleepy at all’ to ‘extremely sleepy’.

Not sleepy at all Extremely sleepy

How thirsty do you feel? The scale ranges from ‘not thirsty at all’ to ‘extremely thirsty’.

Not thirsty at all Extremely thirsty

Appendix 1b: Food Portion Size Question Booklet

Portion Size Question Booklet

Date:

Time:

Subject ID Number:

Instructions for Use:

1. Today you will be presented with 11 different foods/drinks in various portion sizes; each will be displayed in an individual booth, and classified as a snack food, meal or beverage.
2. When you first walk into the test room, you will be instructed in which booth to go to first. The booth numbers will be noted on the top of each page in the booklet. You will therefore need to turn to the corresponding answer page for each booth number.
3. At each booth you will be given 2 minutes to answer 4 questions
4. One question will be on portion sizes.
   You will then be instructed when you should begin answering the questions at each booth; for this particular question you will then write down the number of portions of X food/drink that is presented in front of you. The portion sizes of all food/drink items can be written as a full number (e.g. "1") or as a fraction (e.g. "0.5" or "1/2").

   A portion is defined as:

   "***The quantity of food/drink that YOU would consume on one eating/drinking occasion"***

   Before answering each question it is important for you ask yourself:
   "Would I be able to consume all of that food/drink at this moment in time?"
   If you think "yes" then you should class this as one portion you would note this as demonstrated in the box below;

   Booth 1:
   "How many portions of (food/drink) are in this (container type)": | 1 |

However if you think that the food/drink presented before you is one and a half times the amount YOU would be able to consume based on classification (e.g. meal/snack/beverage) then you would write **1.5** in the box, or write **2** if it is double the amount YOU would consume, and so on.

5. One question will ask:
   "How does this serving compare to your usual portion of X food/drink?"
   Please mark your answer clearly with a vertical trait on one of the two scales in a position which reflects your response most accurately.

   The scales range from a lot smaller to a lot larger. Example:

6. One question will ask:
   "How much fat do you think this portion contains?"
   Please mark your answer clearly with a vertical trait on one of the two scales in a position which reflects your response most accurately.

   The scales range from no fat at all to extremely high in fat. Example:

7. One question will ask;
   "How many calories do you think this portion contains?"
   Please mark your answer clearly with a vertical trait on one of the two scales in a position which reflects your response most accurately.

   The scales range from no calories at all to extremely high in calories. Example:

8. At the end of the 2 minutes you will be asked to move to the booth on your right. This means that if you are currently at booth 11, you will move round to booth number 1. Again you will be instructed when to start and will be given 2 minutes to complete the 4 questions on the next food/drink in front of you.

9. You will continue using this method of rotation until you have visited and recorded all 11 food/drink items. This will indicate the end of the session for you.

Please note the order of the above four questions in your question booklet may vary in order for each session.

Booth 1: (name of food & classification (e.g. snack food, meal or beverage) indicated here)

"How many portions of (food/drink) are in this (container type)": ☐

Booth 2: (name of food and classification indicated here)

"How many portions of (food/drink) are in this (container type)": ☐

Booth 3: (name of food and classification indicated here)

"How many portions of (food/drink) are in this (container type)": ☐

Booth 4: (name of food and classification indicated here)

"How many portions of (food/drink) are in this (container type)": ☐

Booth 5: (name of food and classification indicated here)

"How many portions of (food/drink) are in this (container type)": ☐

Booth 6: (name of food and classification indicated here)

"How many portions of (food/drink) are in this (container type)": ☐

...etc. until booth 11

Booth 1: (name of food and classification indicated here)

How does this portion compare to your usual portion of X food/drink?

A lot smaller A lot larger

Booth 2: (name of food and classification indicated here)

How does this portion compare to your usual portion of X food/drink?

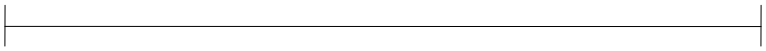
A lot smaller A lot larger

...etc. until booth 11

Booth 1: (name of food and classification indicated here)

How much fat do you think this portion of X contains?

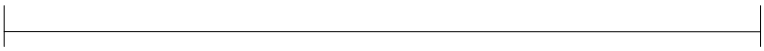
No fat at all Extremely high in fat



Booth 2: (name of food and classification indicated here)

How much fat do you think this portion of X contains?

No fat at all Extremely high in fat

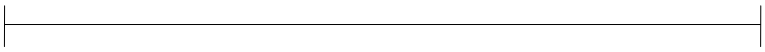


...etc. until booth 11

Booth 1: (name of food and classification indicated here)

How many calories do you think this portion of X contains?

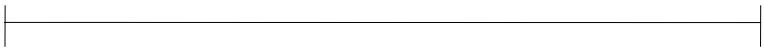
No calories at all Extremely high in calories



Booth 2: (name of food and classification indicated here)

How many calories do you think this portion of X contains?

No calories at all Extremely high in calories



...etc. until booth 11

Appendix 2a: Advertisements

The University of Chester is Conducting a Study on Portion Size

VOLUNTEERS WANTED

Date: From September - December 2010
Location: On Campus

We are conducting a study to investigate into the portion sizes of various foods and drinks that people may consume around campus/on the go.

What would this involve?

This test will involve the observation of different food items and answering a short questionnaire on each item.

Participants will be required to attend a 30 minute screening session followed by three testing sessions each lasting a maximum of 45 minutes.

You must be...

- ✓ **Aged between 18-45**
- ✓ **Non-Smokers**
- ✓ **Healthy**
- ✓ **Non-Dieting**

For the testing sessions you will be asked to consume your usual breakfast at 08:30 am, consume a free snack at 10:30 and attend our session at 12:00 am on all three occasions.

What will I receive?

All volunteers will receive a free snack at each session and a £20 Tesco gift voucher on completion of all three sessions in compensation for their time.

Interested?

Please call Jessica on 00000000000 for more information or e-mail

Appendix 2b: Initial Information Letter

Dear (subject name),

Re: Study on portion sizes

Thank you for recently showing an interest in participating in this study on portion sizes. The following information will provide you of details about the study, its location, the study timetable, when you will be required to attend and at what times.

We are conducting a study to investigate into the portions sizes of various foods and drinks that people consume around campus/on the go, with an aim to better understand food choice trends in this population.

You will be required to attend a 15 minute screening session followed by three testing sessions each lasting a maximum of 20 minutes.

The screening sessions will be held on Mondays and Thursday, however if this is inconvenient then these days can be negotiable. The test sessions will be held on campus in the Cloisters building on the following dates:

…….
…….
…….

The testing sessions will involve your observation of different food items and answering of a short questionnaire on each item. Before the testing sessions you will be asked to consume your usual breakfast at 08:30 am and the whole of a chocolate bar that we provide at 10:30 am, your attendance at the lab it not required for either of these. You will then attend our test sessions at the lab at 12:00am on all three occasions.

You will receive a £20 supermarket gift voucher on completion of all three sessions in compensation for your time.

If you feel you will be able to meet these requirements please contact me either by email on or by telephone on

Kind Regards,

Jessica Dodd

Appendix 2c: Telephone Pre-screening Interview

A telephone pre-screening interview will be conducted on potential candidates, subject to their permission. The telephone interview will include all or a selection of questions, depending on the answers provided (see below). Prior to the telephone interview, the subject will receive information about the study location and timetable, including when the study will run, how often they will need to attend and at what times. If the subject feels able to meet the requirements of the timetable, we will provide them with details of the study as described in the PIS. They will then be offered the opportunity to ask any questions. After this, verbal consent to undertake the telephone interview will be obtained from all candidates as follows:

Interviewer: *(*After candidate receives information on the study as per PIS)

Are you still interested in participating?

If the candidate replies "NO" the investigator says:

Thank you for your time. Please feel free to call us again for a future study.

If the candidate replies "YES" the investigator says:

Thank you. To confirm your eligibility I would like to schedule an appointment for you for a telephone screening session. This session will take about 15 minutes. It involves answering 16 questions on for example, age, weight, height, weight loss history, physical activity, etc. All the information you provide will be kept confidential and you can refrain from answering any questions you do not wish answer.

Do you agree to this?

Answer:	

If the candidate replies "NO" the investigator says:

Thank you for your time. Please feel free to call us again for a future study.

If the candidate replies "YES", the investigator offers to conduct the telephone pre-screening session now or schedules a date and time at the subject's convenience, and says:

DAY ……..

TIME ……..

Thank you. Could you please leave us your name, telephone number and e-mail address, should we need to contact you:

NAME ……

TELEPHONE ……

E-MAIL ……

INTERVIEW QUESTIONS.

Q1. *Could you please tell me your age?*

Age	
18 - 45 yr	<18 or >45 yr
Eligible	**Non-eligible**

If above criteria are not met, interviewer says:
"I am sorry, but unfortunately our research study requires participants between the ages of 18 – 45 years. However, we thank you for your interest and invite you to call us again for a future study."

If the above criteria are met, interviewer proceeds to Question 2.

Q2. *Could you please tell me your approximate weight and height?*

Weight	
Height	

Interviewer consults BMI chart and establishes:		
BMI between 18.0 and 27	**Eligible**	
BMI <18 or >27.9		**Not eligible**

If above criteria are not met, interviewer says:
"I am sorry, but unfortunately our research study includes some strict criteria, which makes our design unsuitable for you on this occasion. However, we thank you for your interest and invite you to call us again for a future study."

If above criteria are met, interviewer proceeds to Question 3.

Q3. *Could you please answer YES / NO to the following question?*

	YES	NO
*Have you **intentionally** lost weight over the last ten years?*		

If subject answers YES, interviewer proceeds to Question 4.
If subject answers NO, interviewer proceeds to Question 6.

Q4.

What is the largest amount of weight you have lost?	≤ 5kg (11lb)	≥ 5kg (11lb)

If weight loss is ≤ 5kg (11lb), interviewer proceeds to Question 6.
If weight loss is ≥ 5kg (11lb), interviewer proceeds to Question 5.

Q5.

Have you regained the weight you have lost?	YES	NO
CRITERIA	**Non-eligible**	**Eligible**

If above criteria are not met (Question 5), interviewer says:
"I am sorry, but unfortunately our research study includes some strict criteria, which makes our design unsuitable for you on this occasion. However, we thank you for your interest and invite you to call us again for a future study."

If above criteria are met, interviewer proceeds to Question 6.
Interviewer: *Thank you. Could you please answer YES/NO to the following questions*:

Q6-15

	YES	NO
6. *Do you have any condition at the moment that affects your diet, appetite or food intake?* *If so, which condition?* Cannot participate if he has: diabetes, cardio-vascular disease, high levels of blood lipids, flu, other conditions affecting appetite or food intake.		
7. *Do you smoke?*		
8. *Are you following any diet to gain or lose weight?*		
9. *Are you taking any supplements to gain or lose weight?*		
10. *Do you have any food allergies, food intolerances or food restrictions?* Cannot participate if they have an allergy / don't eat gluten, dairy products, nuts, or are vegan. Vegetarians are eligible.		
11. *Are you taking any prescription medications or supplements which may affect your appetite?*		
12. *Are you an athlete in training?*		
13*. Are you involved in intense physical activity for >10 hours per week?*		
14. *Do you have prior knowledge of this study?*		
15. *Have you had any nutrition training?*		
CRITERIA	**Non-eligible**	**ELIGIBLE**
	YES	NO
16. *Do you eat breakfast regularly?*		

If the above criteria are not met (Q6-Q16), the interviewer says:
"I am sorry but unfortunately our research study includes some strict criteria, which makes our design unsuitable for you on this occasion. However, we thank you for your interest and we invite you to call us again for a future study."

If the above criteria are met, investigator proceeds to Question 17.

	YES	NO
17. *Would you be able to come to the lab on three different days during (month) – (month), at 10:00 am for 45 minutes?*		
CRITERIA	**ELIGIBLE**	**Non-eligible**

If the above criteria (Q17) are not met, the investigator says:
"Thank you for your time. If you decide at a later date that you would be free to attend the study sessions, please call back and let me know."

If all the above criteria are met (Q1-Q17), the investigator says:
"Thank you for your answers. You may be eligible for the study. We will now post you a Participant Information Sheet containing information about the study and a consent form for you to read. Please take time to read the information carefully and discuss it with others if you wish. Please contact me if there is anything that is not clear or if you would like more information.

To confirm your eligibility, you will need to attend a ***screening session in the lab*** *before the study begins. This session will take about 30 minutes. You will be weighed and measured in private and asked to fill in some questionnaires.*

You can:

A) *Schedule an appointment with us by calling us back after you have received and read the information sheet and the consent form*

B) *Schedule a preliminary date for the lab screening today*

What would you prefer to do?

If the candidate replies;

A) The Investigator says: *"Thank you for your time. After you receive the information in the mail, we would like to hear from you within 48 h of you receiving the letter, but you can take more time if you need to. Please call us back when you are ready.*

Could you please leave us your name and address so we can send the forms to you?

NAME ……
ADDRESS ……
……

B) The investigator says: "*Thank you. After you receive the information, if you decide that you are not interested, could you please call us back within 48 h of receiving the letter if possible, to confirm that you are not interested and to cancel the lab screening appointment. If you are interested, please sign the consent form and bring it with you on the day of lab screening. You don't need to call us back for confirmation of attendance."*

<u>The date of your screening session will be:</u>

(This will be scheduled considering a period of at least 48 h after subject receives post to give time to read and consider the information)

DAY ……..
TIME ……..

Could you please leave us your name and address so we can post the forms to you and also a telephone number and e-mail address should we need to contact you more urgently, i.e. if in need to re-schedule the lab screening:

NAME ……..
ADDRESS ……
TELEPHONE ……
E-MAIL ……

Appendix 2d: VAS Scales – Familiarity and liking

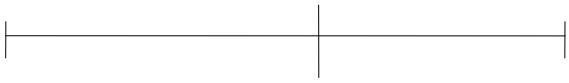
Visual Analogue Scale (VAS) Questionnaire
Familiarity and Liking

Subject ID number _____

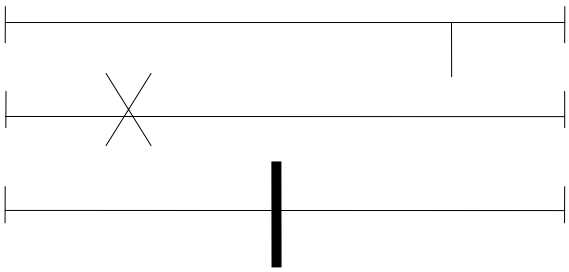
Instructions for Use

1) Please read the question above each VAS scale carefully
2) Place a vertical line across the scale in a position which reflects your response most accurately
3) Look at the examples overleaf to help you

Mark the line like this:



But **NOT** like this:



How familiar are you with X food/drink?

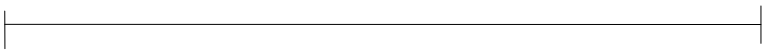
The scale ranges from ‘not familiar at all’ to ‘extremely familiar’.

Not familiar at all Extremely familiar

How much do you like X food/drink?

The scale ranges from ‘I do not like it at all’ to ‘I extremely like it’.

I do not like it at all I extremely like it



Appendix 2e: Three Factor Eating Questionnaire

Please answer questions 1 - 36 by circling either T for true or F for false.

1	When I smell a sizzling steak or see a juicy piece of meat, I find it very difficult to keep from eating, even if I have just finished a meal.	T	F
2	I usually eat too much at social occasions, like parties and picnics.	T	F
3	I am usually so hungry that I eat more than three times a day.	T	F
4	When I have eaten my quota of calories, I am usually good about not eating any more.	T	F
5	Dieting is so hard for me because I just get too hungry.	T	F
6	I deliberately take small helpings as a means of controlling my weight.	T	F
7	Sometimes things taste so good that I keep on eating even when I am no longer hungry.	T	F
8	Since I am often hungry, I sometimes wish that while I am eating, an expert would tell me that I have had enough or that I can have something more to eat.	T	F
9	When I feel anxious, I find myself eating.	T	F
10	Life is too short to worry about dieting.	T	F
11	Since my weight goes up and down, I have gone on reducing diets more than once.	T	F
12	I often feel so hungry that I just have to eat something.	T	F
13	When I am with someone who is overeating, I usually overeat too.	T	F
14	I have a pretty good idea of the number of calories in common food.	T	F
15	Sometimes when I start eating, I just can`t seem to stop.	T	F
16	It is not difficult for me to leave something on my plate.	T	F
17	At certain times of the day, I get hungry because I have got used to eating then.	T	F

18	While on a diet, if I eat food that is not allowed, I consciously eat less for a period of time to make up for it.	T	F
19	Being with someone who is eating often makes me hungry enough to eat also.	T	F
20	When I feel blue, I often overeat.	T	F
21	I enjoy eating too much to spoil it by counting calories or watching my weight.	T	F
22	When I see a real delicacy, I often get so hungry that I have to eat right away.	T	F
23	I often stop eating when I am not really full as a conscious means of limiting the amount that I eat.	T	F
24	I get so hungry that my stomach often seems like a bottomless pit.	T	F
25	My weight has hardly changed at all in the last ten years.	T	F
26	I am always hungry so it is hard for me to stop eating before I finish the food on my plate.	T	F
27	When I feel lonely, I console myself by eating.	T	F
28	I consciously hold back at meals in order not to gain weight.	T	F
29	I sometimes get very hungry late in the evening or at night.	T	F
30	I eat anything I want, any time I want.	T	F
31	Without even thinking about it, I take a long time to eat.	T	F
32	I count calories as a conscious means of controlling my weight.	T	F
33	I do not eat some foods because they make me fat.	T	F
34	I am always hungry enough to eat at any time.	T	F
35	I pay a great deal of attention to changes in my figure.	T	F
36	While on a diet, if I eat a food that is not allowed, I often then splurge and eat other high calorie foods.	T	F

Please answer questions 37 – 51 by circling the number highlighting your most appropriate answer.

37 How often are you dieting in a conscious effort to control your weight?

1	2	3	4
rarely	sometimes	usually	always

38 Would a weight fluctuation of 5 lbs affect the way you live your life?

1	2	3	4
not at all	slightly	moderately	very much

39 How often do you feel hungry?

1	2	3	4
only at mealtimes	sometimes between meals	often between meals	almost always

40 Do your feelings of guilt about overeating help you to control your food intake?

1	2	3	4
never	rarely	often	always

41 How difficult would it be for you to stop eating halfway through dinner and not eat for the next four hours?

1	2	3	4
easy	slightly difficult	moderately difficult	very difficult

42 How conscious are you of what you are eating?

1	2	3	4
not at all	slightly	moderately	extremely

43 How frequently do you avoid "stocking up" on tempting foods?

1	2	3	4
almost never	seldom	usually	almost always

44 How likely are you to shop for low calorie foods?

1	2	3	4
unlikely	slightly unlikely	moderately unlikely	very likely

45 Do you eat sensibly in front of others and splurge alone?

1	2	3	4
never	rarely	often	always

46 How likely are you to consciously eat slowly in order to cut down on how much you eat?

1	2	3	4
unlikely	slightly unlikely	moderately likely	very likely

47 How frequently do you skip dessert because you are no longer hungry?

1	2	3	4
almost never	seldom	at least once a week	almost every day

48 How likely are you to consciously eat less than you want?

1	2	3	4
unlikely	slightly likely	moderately likely	very likely

49 Do you go on eating binges though you are not hungry?

1	2	3	4
never	rarely	sometimes	at least once a week

50 On a scale of 0 to 5, where 0 means no restraint in eating (eating whatever you want, whenever you want it) and 5 means total restraint (constantly limiting food intake and never `giving in`), what number would you give yourself?

0
eat whatever you want, whenever you want it
1
usually eat whatever you want, whenever you want it
2
often eat whatever you want, whenever you want it
3
often limit food intake, but often ` give in `
4
usually limit food intake, rarely `give in`
5
constantly limiting food intake, never `giving in`

51 To what extent does this statement describe your eating behaviour? "I start dieting in the morning, but because of any number of things that happen during the day, by evening I have given up and eat what I want, promising myself to start dieting again tomorrow.

1	2	3	4
not like me	little not like me	pretty good description of me	describes me perfectly

Coding Instructions for Three Factor Eating Questionnaire

1) To calculate scores without the computer programme:

Questions 1-36 - The correct answer gains one point. For details of the correct answer see below:

Question Number	Correct answer
1	True
2	True
3	True
4	True
5	True
6	True
7	True
8	True
9	True
10	False
11	True
12	True
13	True
14	True
15	True
16	False
17	True
18	True
19	True
20	True
21	False
22	True
23	True
24	True
25	False
26	True
27	True
28	True
29	True
30	False
31	False
32	True
33	True
34	True
35	True
36	True

Questions 37-51
Split the responses to each question at the middle.
If the question is a 'positive' question, score 0 for circling 1 or 2 and score 1 for circling 3 or 4.
If the question is a 'negative' question, score 1 for circling 1 or 2 and 0 for circling 3 or 4.
Details of the question type are given below:

Question number	Question type
37	Positive
38	Positive
39	Positive
40	Positive
41	Positive
42	Positive
43	Positive
44	Positive
45	Positive
46	Positive
47	Negative
48	Positive
49	Positive
50	Positive
51	Positive

To calculate a score for each of the three factors, you will need to know which question refers to which factor. For details of this see below:

a) Cognitive Restraint = 4, 6, 10, 14, 18, 21, 23, 28, 30, 32, 33, 35, 37, 38, 40, 42, 43, 44, 46, 48 and 50
Possible score for this category = 0 – 21

b) Disinhibition = 1, 2, 7, 9, 11, 13, 15, 16, 20, 25, 27, 31, 36, 45, 49, 51
Possible score for this category = 0 – 16

c) Hunger = 3, 5, 8, 12, 17, 19, 22, 24, 26, 29, 34, 39, 41, 47
Possible score for this category = 0 – 14

When you have calculated score for each factor, use the table below to determine whether or your subject is eligible.

Eating Behaviour	**Score**	
Cognitive restraint	< 10	≥ 11
Disinhibition	< 8	≥ 9
Hunger	< 7	≥ 8
	Eligible if complies with D + C and/or H	**Non-eligible if does not comply with D**

Subjects meeting D alone may be considered for the reserve list.

Appendix 3a: Participant Information Sheet (PIS)

The University of Chester

Participant Information Sheet

Portion Size Study

You are being invited to take part in a research study. It is important that you understand why the research is being done and what it will involve. Please read the following information carefully and discuss it with others if you wish. Please do not hesitate to ask us if there is anything that is not clear or for more information. Please take your time to decide whether or not you wish to participate.

THANK YOU FOR TAKING THE TIME TO READ THIS

What is the purpose of the study?

We are conducting a study to investigate into the portion sizes of various foods and drinks that people may consume around campus/on the go, with an aim to better understand food choice trends in this population.

Why have I been invited to take part?

You have been chosen as a potential candidate for this study. This is because the telephone screening session has indicated that you may meet the study eligibility criteria and the data you provide us with will likely be valid for our research purpose.

Do I have to take part?

It is up to you to decide whether or not you would like to take part.
If you decide to take part you must keep this information sheet and sign the consent form.
If you decide to take part you are still free to withdraw at any time and without giving a reason. A decision to withdraw at any time, or a decision not to take part, will not affect your university or legal status in any way.

What will happen to me if I decide to take part?

You will be asked to **return your signed consent form to the researcher on the day of laboratory screening**, prior to any procedures taking place. If laboratory screening confirms that you meet the study criteria, the researcher will discuss with you suitable dates and times for attendance at test sessions, and you will receive a letter confirming this.

The study involves attending the laboratory at 12:00 am on three separate test days, each lasting a maximum of 20 minutes. You will be asked to consume your usual breakfast at 08:30 am on each day, making sure that you consume the same breakfast for each test day after an overnight fast, and consume a free snack at 10:30 am on each test day.

On your arrival you will be given instructions on test activities for that day. These will include the completion of two short questionnaires.
Following this, the test will involve the observation of eleven different food items and answering a short questionnaire for each item.
This will be the end of the session for you. You will be asked to return on two more occasions to complete the study.

What do I have to do?

- On the screening day your weight and height will be taken and you will be asked to complete two screening questionnaires.
- On the day before the test you will be asked to consume no food or drink (except for non-carbonated water) between 8:00 pm and 8:30 am, apart from your usual breakfast at 8:30 am, making sure that you consume the same breakfast for each test day.
- You will be asked not to drink alcohol on the day before the test and to keep your activity and evening meals similar to those on other pre-test days.
- On the day of the test you must not eat or drink anything except non-carbonated water for four hours beforehand, i.e. from 8:30 am to 12:30 am, apart from the free snack provided at 10:30 am.

What are the possible disadvantages and risks of taking part?

There are no disadvantages or risks foreseen in taking part in this study.

What are the possible benefits of taking part?

There are no personal benefits from taking part in this study. All participants who complete the study will receive a **£20** Tesco gift voucher upon the completion of all three test days and a free snack on each test day.

What if something goes wrong?

If you wish to complain or have any concerns about any aspect of the way you have been approached or treated during the course of this study, please contact Professor Sarah Andrew, Dean of the School of Applied and Health Sciences, University of Chester, Parkgate Road, Chester, CH1 4BJ, United Kingdom, +44 (0)1244 513055.

If you are harmed by taking part in this research project, there are no special compensation arrangements. If you are harmed due to someone's negligence (but not otherwise), then you may have grounds for legal action, but you may have to pay for this.

Will my taking part in this study be kept confidential?

All information which is collected about you during the course of the research will be kept strictly confidential. Only the lead researcher, their academic supervisor and the research technician will have access to such information. Where possible the data will be coded for anonymity. However, the lead researcher will take full responsibility for the secure storage of any material containing identifiable information.

What will happen to the results of the research study?

The results will be written up in the form of a Masters dissertation. This will be obtainable from the University of Chester library after March 2013.
The results may also be presented at a conference, e.g. The European Conference on Obesity, and published in a peer reviewed journal.
Individuals who participate will not be identified in any report or publication.

Who is organizing and funding the research?

The Faculty of Applied Health Sciences, University of Chester, is funding and organising the research. Persons involved in conducting the research will not receive any payment for their involvement.

Who has reviewed the study?

The study has been reviewed by the Faculty Research Ethics Committee, University of Chester.

Who may I contact for further information?

If you would like more information about the research before you decide whether or not you would be willing to take part, please contact:

Jessica Dodd - Department of Biological Sciences, Cloisters 106, University of Chester, Parkgate Road
CH1 4BJ
Email address:

Thank you for your interest in this research.
If you decide not to take part, please call/email us at the numbers above to let us know.

Appendix 3b: Consent Form

UNIVERSITY OF CHESTER
CONSENT FORM

Title of project: Study on portion sizes

Name of researcher: Miss Jessica Dodd , MSc Student, Dept of Biological Sciences

Name of academic supervisor: **Dr Eva Almiron-Roig**, Senior Lecturer, Dept of Biological Sciences

	Please initial box
1) I confirm that I have read and understood the information sheet dated ….....for the above study and have had the opportunity to ask any questions.	☐
2) I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason .	☐
3) I agree to take part in the above study.	☐
4) **Optional future participation**. If you agree to be contacted by the above academic supervisor for a related study in the future, please check this box.	☐

Name of participant	Date	Signature
Name of person taking consent (if different from researcher)	Date	Signature
Researcher	Date	Signature

(1 for participant; 1 for researcher)

Appendix 3c: "Food Diary" Questionnaire

Name……..

Q1.) Please describe what you consumed yesterday for your evening meal (amount and type of food and drink) and at what time.

Q2.) Please describe any physical activity you performed since yesterday after 5 p.m and until today before 8:00 a.m.

Q3.) Please describe what you consumed this morning for breakfast (amount and type of food and drink) and at what time.

Appendix 3d: Letter of approval from the Research Ethics Committee

University of Chester

Faculty of Applied Sciences
Research Ethics Committee

Tel 01244 511740
Fax 01244 511302
frec@chester.ac.uk

1st October 2010

Dear Jessica,

Study title: **The effect of energy density on portion size.**
FREC reference: **451/10/JD/BIOL**
Version number: **1**

Thank you for sending your application to the Faculty of Applied Sciences Research Ethics Committee for review.

I am pleased to confirm a favourable ethical opinion for the above research, provided that you comply with the conditions set out in the attached document, and adhere to the processes described in your application form and supporting documentation. However, the Committee would like to make the following recommendations:-

- Your explanation for the inclusion of sex as a between-subjects factor in your data analysis remains unjustified by the stated hypotheses. If sex is a factor, then your hypotheses should reflect that you expect differences between the sexes. If you have no grounds to expect sex differences, then sex is not a part of the analysis.
- With validated questionnaires, if the words/expressions used are unfamiliar to the new target sample, then they have to be revised, otherwise the responses are questionable.
- Reduce the length of the Participant Information Sheet to two pages by reducing the page margins.

The final list of documents reviewed and approved by the Committee is as follows:

Document	Version	Date
Application Form	1	July 2010
Application Form	2	September 2010
Response to the FREC request for further information and clarification	1	September 2010
Appendices 1 - 18	2	September 2010

Appendix 4a: Characteristics, amounts displayed and actual portion sizes of test foods and drinks based on reference amounts from the FSA's guidance scheme

Energy content as indicated in product label or from manufacturer's website. Energy density codes for each food and drink based on Rolls & Barnett (2000): VLED = very low energy density (>0.6kcal/g or ml); LED = low energy density (0.6-1.4kcal/g or ml); MED = medium energy density (1.5-3.9kcal/g or ml); HED = high energy density (≥4.0kcal/g or ml). Unit conversions: 1 oz = 28.35g; 1 fluid oz = 29.57ml; specific gravity (in g/ml) of full-fat milk = 1.031; of semi-skimmed milk = 1.034; of Cola = 1.040; of fresh orange juice = 1.040; of cranberry juice = 1.040

Abbreviations: D, drink; FSA, Food Standards Agency; M, meal; S, snack.

Food	Type of Food	Food Unit	Portion Size Displayed[34]	Energy Load (kcal/portion displayed)	Energy Density (kcal/g)	Manufacture's reference amount corresponding to one portion (or serving).	FSA reference amount corresponding to one portion[35] (g)	Number of Portions Based on FSA
Carton of fresh orange juice[1]	D (VLED)	Single item	200ml (208g)	81.12	0.39	200ml	160g	1.3
Pork pies[2]	S (HED)	Multi-item (2 units)	130g	534.30	4.11	65	140g	0.9
Cheese and crackers[3]	S (HED)	Multi-item (8 units of cheese on cracker)	55g	245.85	4.47	30 + 25	40 + 33	0.8
Cola drink[4]	D (VLED)	Single item	500ml (520g)	218.40	0.42	250ml	250ml (260g)	2
Whole milk[5]	D (LED)	Single item	568ml (586g)	375.04	0.64	200ml	200	2.9
Hot chocolate[6]	D (LED)	Single item	473ml (488g)	483.12	0.99	473ml (488g)	200	2.4
Peanut butter on toast[7]	M (MED)	Multi-item (2 slices shown)	92.4g	285.52	3.09	10 + 36	25 + 22	2.1
Country vegetable soup[8]	M (VLED)	Single item	400g	152.00	0.38	200	220	1.8
Fruit salad[9]	S (LED)	Single item	134g	89.78	0.67	220	115	1.2

Light vanilla yoghurt[10]	S (VLED)	Single item	190g	95.00	0.50	190	125	1.5
A banana[11]	S (LED)	Single item	140g	124.60	0.89	140	100	0.8
Croissant[12]	S (HED)	Single item	44g	188.32	4.28	44	60	0.7
Chicken salad bowl with a caesar dressing[13]	M (LED)	Single item	325g	344.50	1.06	77 + 40 +20	130 + 80 + 15	1.3
Biscuit cereal with semi-skimmed milk[14]	M (LED)	Multi-item (2 units cereal, 1 unit milk)	192.5g	202.13	1.05	37.5 + 200ml	20 + 100ml	1.7
Instant chicken flavoured noodles[15]	M (MED)	Single item	300g	525.00	1.75	150	280	1.1
Flapjack[16]	S (HED)	Single item	28g	129.92	4.64	28	60	0.5
Chocolate bar[17]	S (HED)	Single item	75g	408.00	5.44	75	47[a]	1.6
Blueberry muffin[18]	S (HED)	Single item	70g	272.30	3.89	70	85	0.8
Cereal breakfast bar[19]	S (HED)	Single item	45g	243.45	5.41	45	33	1.4
Cottage cheese on crispbreads[20]	S (LED)	Multi-item (2 units cheese on cracker)	155g	218.55	1.41	125 + 10	112 + 10	2.1
Sausage roll[21]	S (MED)	Single item	140g	498.40	3.56	140	60	2.3
Beans and cheese on toast[22]	M (LED)	Multi-item (2 units bread, 1 unit beans and cheese)	522.4g	626.88	1.20	210 + 36	135 + 40 + 22	2.4
Malt loaf[23]	S (MED)	Single item	64g	220.16	3.44	64	35	1.8

Crisps[24]	S (HED)	Single item	50g	264.50	5.29	50	40	1.3
Peanuts[25]	S (HED)	Single item	50g	319.50	6.39	50	50	1.0
Macaroni and cheese[26]	M (LED)	Single item	410g	389.50	0.95	205	220	1.9
Chicken in black bean sauce with rice[27]	M (LED)	Multi-item (1 unit chicken & sauce, 1 unit rice)	500g	500.00	1.00	500	400	1.3
Cottage pie with broccoli and carrots[28]	M(LED)	Multi-item (1 unit pie, 1 unit veg)	460g	280.60	0.61	300	310 + 85 + 60	1.0
Ice cream[29]	S (MED)	Single item	400g	968.00	2.42	100	75	5.3
Chicken sandwich roll, chocolate bar and a can of cola drink[30]	M (MED)	Multi-item (1 unit roll, 1 unit chocolate, 1 unit cola)	595.2	999.94	1.68	167 + 42.5 + 330ml	130 + 56 + 250ml	1.3
Meat and barbeque sauce pizza with a garlic and herb dip[31]	M (HED)	Multi-item (1 unit pizza, 1 unit dip)	188g	821.56	4.37	80 + 28	200 + 12	1.6
Cheese & ham quiche and coleslaw[32]	M (MED)	Multi-item (1 unit quiche, 1 unit coleslaw)	200g	370.00	1.85	100 + 100	140 + 45	1.5
Bacon and cheese panini, crisps and cranberry juice[33]	M (MED)	Multi-item (1 unit Panini, 1 unit crisp, 1 unit juice)	378g	669.06	1.77	145 + 25 + 200ml	130 + 40 + 160	1.0

[1] "Sainsburys", smooth orange juice carton, as sold.

[2] “Sainsburys”, two crusty bake snack pork pies, as sold.
[3] “Sainsburys”, british medium cheddar cheese, sliced from packet; “Ritz”, crackers, served from packet.
[4] “Coca-Cola”, 500ml container as sold.
[5] “Sainsburys”, 568ml whole milk container as sold.
[6] “Starbucks Coffee Company”, signature hot chocolate, made with full-fat milk, no cream.
[7] “Sainsburys”, basics crunchy peanut butter, served from jar; “Sainsburys”, medium white sliced loaf, served toasted.
[8] “Sainsburys”, basics vegetable soup, served from can.
[9] “Nature’s Finest”, pear, peach and pineapple in juice, served from pack, drained.
[10] “Muller Light”, smooth vanilla yoghurt, as sold.
[11] “Sainsburys”, whole fresh banana, presented with skin (portion size calculated based on flesh only).
[12] “Sainsburys”, all-butter croissant, served from packet.
[13] “Sainsburys”, basics sliced cooked chicken breast, served from packet; “Sainsburys”, basics young leaf salad, served from packet; “Sainsburys”, Caesar dressing, served from bottle.
[14] “Weetabix”, breakfast cereal, served from pack (dry); “Sainsburys”, semi-skimmed milk, served from carton.
[15] “Batchelors”, chicken flavour super noodles, served as per instructions.
[16] “The Fabulous Bakin’ Boys”, golden oaty flapjack finger, served as sold.
[17] “Galaxy”, a little extra chocolate bar, as sold.
[18] “Sainsburys”, blueberry muffin, as sold.
[19] “Jordans”, luxury absolute nut cereal bar, as sold.
[20] “Longley Farm”, natural cottage cheese, served from container; “Ryvita”, wholegrain rye crispbreads, served from pack.
[21] “Ginsters”, large sausage roll, as sold.
[22] “Sainsburys”, baked beans in tomato sauce, served from can; “Sainsburys”, british medium cheddar cheese, grated from packet; “Sainsburys”, medium white sliced loaf, served toasted.
[23] “Soreen Snack”, malt loaf served with butter, as sold.
[24] “Walkers”, grab bag ready salted crisps, as sold.
[25] “Sainsburys”, basics salted peanuts, served from packet.
[26] “Sainsburys”, macaroni cheese, served from can.
[27] “Morrisons”, chicken in black bean sauce, served as per instructions.
[28] “Sainsburys”, basics cottage pie, served as per instructions.
[29] “Sainsburys”, taste the difference Madagascan vanilla Devon farmhouse ice-cream tub, as sold.
[30] “Rustlers”, hot subs, chicken, bacon and cheese club roll, served as per instructions; “Twix Xtra”, twin finger chocolate bar, as sold; “Coca-Cola”, 330ml container as sold.

[31] “Domino’s Pizza”, pizza slices, served from box; “Domino’s Pizza”, garlic and herb dip, as sold.
[32] “Sainsburys”, quiche Lorraine, slice served from box; “Sainsburys”, basics coleslaw, served from pot.
[33] “UGO’S”, Bacon, cheese and mustard mayonnaise Panini, served as per instructions; “Walkers”, ready salted crisps, as sold; “Ocean Spray”, cranberry classic juice drink carton, as sold.
[34] For portion size and energy load for individual food items in multi-item foods see Appendix 2.
[35] Based on standard, average or medium serving sizes, for FSA portion sizes for individual food items in multi-item foods see Appendix 3.
[a] Based on standard ‘Galaxy’ bar

Appendix 4b: Portion size and energy load for individual food items in multi-item foods

Foods		Portion size of each foods displayed	Energy load of each foods displayed (kcal/portion displayed)	Total portion size	Total energy load (kcal/portion displayed)
Cheese and crackers	Cheese	30g	123	55g	246
	Crackers	25g	123		
Peanut butter on toast	Peanut butter	20g	122	92.4g	286
	Toast	72.4g	164		
Chicken salad bowl with a caesar dressing	Chicken	230g	248	325g	345
	Salad	75g	14		
	Caesar dressing	20g	83		
Biscuit cereal with semi-skimmed milk	Biscuit cereal	37.5g	127	192.5g	201
	Semi-skimmed milk	150ml (155g)	74		
Cottage cheese on crispbreads	Cottage cheese	125g	143	155g	238
	Crispbreads	30g	95		
Beans and cheese on toast	Beans	420g	340	522.4g	627
	Cheese	30g	123		
	Toast	72.4g	164		
Cottage pie with broccoli and carrots	Cottage pie	300g	219	460g	275
	Broccoli and carrots	160g	56		
Chicken sandwich roll, chocolate bar and a can of cola drink	Chicken sandwich roll	167g	439	595.2	995
	Chocolate bar	85g	417		
	Cola drink	330ml (343.2g)	139		
Meat and barbeque sauce pizza with a garlic and herb dip	Meat and barbeque sauce pizza	160g	627	188g	821
	Garlic and herb	28g	194		

	dip				
Cheese & ham quiche and coleslaw	Cheese & ham quiche	100g	262	200g	369
	Coleslaw	100g	107		
Bacon and cheese panini, crisps and cranberry juice	Bacon and cheese panini	145g	434	378g	664
	Crisps	25g	132		
	Cranberry juice	200ml (208g)	98		

Appendix 4c: FSA portion sizes for individual food items in multi-item foods

Foods		FSA portion size of each foods displayed (g)	Portion size of each foods displayed (g)	Portion size based on the FSA for each item	Portion size based on the FSA for multi-item meal total
Cheese and crackers	Cheese	40	30	0.75	0.8
	Crackers	33	25	0.76	
Peanut butter on toast	Peanut butter	25	20	0.80	2.1
	Toast	22	72.4	3.30	
Chicken salad bowl with a caesar dressing	Chicken	130	230	1.77	1.3
	Salad	80	75	0.94	
	Caesar dressing	15	20	1.33	
Biscuit cereal with semi-skimmed milk	Biscuit cereal	20	37.5	1.88	1.7
	Semi-skimmed milk	100	155	1.55	
Cottage cheese on crispbreads	Cottage cheese	112	125	1.12	2.1
	Crispbreads	10	30	3.00	
Beans and cheese on toast	Beans	135	420	3.11	2.4
	Cheese	40	30	0.75	
	Toast	22	72.4	3.29	
Cottage pie with broccoli and carrots	Cottage pie	310	300	0.97	1.0
	Broccoli	85	160	1.10	
	Carrots	60 (total 145)			
Chicken sandwich roll, chocolate bar and a can of cola drink	Chicken sandwich roll	130	167	1.28	1.3
	Chocolate bar[1]	56	85	1.52	
	Cola drink	343.2	343.2	1.00	
Meat and barbeque sauce pizza with a garlic and herb dip	Meat and barbeque sauce pizza	200	160	0.8	1.6
	Garlic and herb	12	28	2.3	

	dip				
Cheese & ham quiche and coleslaw	Cheese & ham quiche	140	100	0.71	1.5
	Coleslaw	45	100	2.22	
Bacon and cheese panini, crisps and cranberry juice	Bacon and cheese panini	130	145	1.12	1.0
	Crisps	40	25	0.63	
	Cranberry juice	160	208	1.30	

[1]Based on standard 'Twix'

Appendix 4d: Photographs of test foods and drinks

In each session, 11 out of the following 33 test foods and drinks were shown in the test room with one food/drink item allocated to each individual booth as shown below. Details of the 33 test foods and their container size are shown below.

Test Room

1. Fresh orange juice

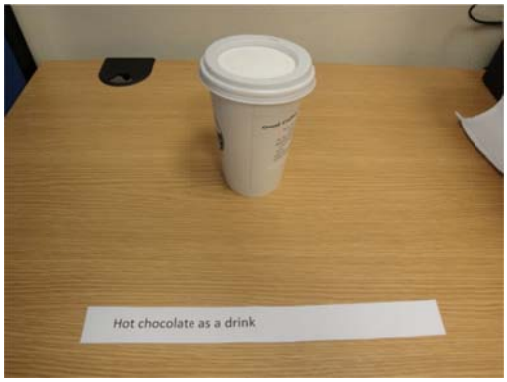
2. Pork pies

3. Cheese and crackers

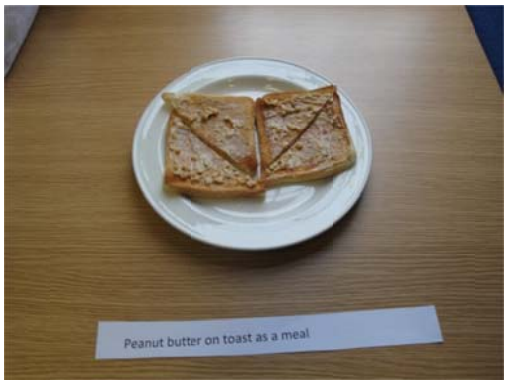
4. Cola drink

5. Whole milk

6. Hot chocolate

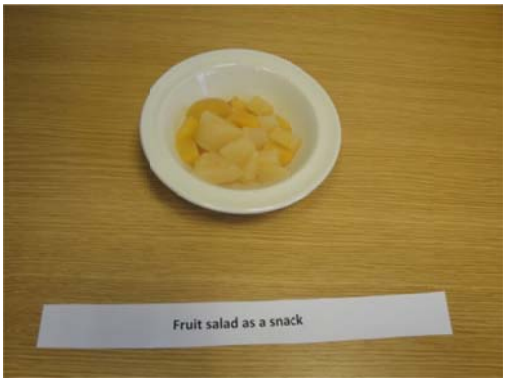


7. Peanut butter on toast



8. Country vegetable soup

9. Fruit salad



10. Light vanilla yoghurt

11. Banana

12. Croissant

13. Chicken salad with caesar dressing

14. Biscuit cereal with semi-skimmed milk

15. Instant chicken flavoured noodles

16. Flapjack

17. Chocolate bar

18. Blueberry muffin

19. Cereal breakfast bar

20. Cottage cheese on crispbreads

21. Sausage roll

22. Beans and cheese on toast

23. Malt loaf

24. Crisps

25. Peanuts

26. Macaroni and cheese

27. Chicken in sauce with rice

28. Cottage pie with vegetables

29. Ice cream

30. Chicken roll, chocolate bar, cola can

31. Meat pizza and dip

32. Quiche and coleslaw

33. Meat panini. crisps, cranberry juice

Food Covers

Appendix 4e: Randomisation procedure for the order of test food presentation

The following sequences refer to the order in which foods will be presented, and have been obtained by a random selection process from 11 independent values (1 through to 33 representing food 1 to food 33).

These sequences were obtained by drawing numbers out of a bag. Numbers 1 to 33 were written down on separate pieces of paper, all pieces of paper were the exact same size and were all folded precisely in half two times, providing a true random number sequence.

Session 1	Sequence
Week 1	23, 4, 5, 30, 32, 9, 31, 17, 20, 14, 10
Week 2	24, 26, 11, 18, 15, 13, 29, 33, 2, 3, 21
Week 3	28, 1, 6, 27, 22, 25, 19, 7, 16, 12, 8

Session 2	Sequence
Week 1	22, 14, 27, 11, 26, 9, 30, 10, 19, 2, 15
Week 2	32, 25, 5, 33, 20, 24, 23, 6, 4, 8, 17
Week 3	18, 12, 31, 3, 28, 29, 13, 16, 7, 1, 21

Session 3	Sequence
Week 1	12, 5, 20, 32, 8, 15, 10, 4, 27, 22, 25
Week 2	29, 14, 16, 30, 21, 28, 13, 6, 3, 1, 31
Week 3	17, 11, 19, 7, 33, 9, 2, 24, 18, 26, 23

Appendix 4f: Randomisation procedure for the portion question order

The following sequences refer to the randomised order of questions in the food portion size question booklet. Each participant has been allocated three sequences obtained by a random selection process from 4 independent values (1 through to 4) representing the following 4 questions:

1.) "How many portions of X are in this (container type)?"
2.) "How does this portion compare to your usual portion of X food/drink?"
3.) "How much fat do you think this portion of X contains?"
4.) "How many calories do you think this portion of X contains?"

These sequences were obtained by drawing numbers out of a bag. Numbers 1 to 4 were written down on separate pieces of paper, all pieces of paper were the exact same size and were all folded precisely in half two times, providing a true random number sequence.

Participant ID	Week 1	Week 2	Week 3
1	3, 4, 2, 1	2, 3, 1, 4	3, 4, 2, 1
2	1, 3, 4, 2	4, 2, 1, 3	2, 1, 3, 4
3	4, 1, 2, 3	4, 2, 1, 3	1, 2, 4, 3
4	3, 1, 4, 2	2, 1, 4, 3	4, 1, 2, 3
5	1, 3, 4, 2	3, 4, 1, 2	3, 1, 4, 2
6	1, 4, 2, 3	2, 3, 1, 4	1, 2, 3, 4
7	4, 2, 1, 3	2, 4, 1, 2	1, 3, 4, 2
8	2, 3, 4, 1	1, 3, 2, 4	3, 2, 4, 1
9	4, 1, 3, 2	3, 4, 2, 1	4, 1, 3, 2
10	1, 2, 4, 3	4, 3, 1, 2	3, 2, 1, 4
11	2, 4, 1, 3	3, 2, 4, 1	1, 3, 4, 2
12	2, 3, 1, 4	2, 1, 3, 4	3, 1, 2, 4
13	1, 3, 2, 4	4, 2, 1, 3,	3, 1, 4, 2
14	4, 2, 1, 3	3, 1, 4, 3	2, 4, 1, 3
15	3, 1, 4, 2	2, 3, 4, 1	2, 3, 1, 4
16	2, 4, 1, 3	1, 4, 3, 2	3, 4, 1, 2
17	4, 3, 2, 1	2, 4, 1, 2	3, 1, 4, 2
18	4, 2, 1, 3	2, 1, 3, 4	1, 3, 2, 4
19	3, 4, 2, 1,	1, 2, 4, 3	4, 1, 2, 3
20	3, 2, 4, 1	1, 2, 3, 4	3, 4, 2, 1
21	3, 2, 1, 4	2, 3, 4, 1	2, 3, 1, 4
22	4, 3, 2, 1	3, 4, 1, 2	1, 4, 2, 3
23	3, 4, 2, 1	1, 4, 3, 2	1, 4, 3, 2
24	1, 3, 4, 2	4, 1, 2, 3	3, 1, 2, 4
25	2, 1, 3, 4	2, 1, 3, 4	3, 4, 1, 2
26	3, 4, 1, 2	3, 1, 4, 2	2, 3, 4, 1
27	2, 4, 3, 1	1, 2, 4, 3	2, 1, 3, 4
28	1, 2, 3, 4	2, 1, 3, 4	3, 1, 4, 2
29	2, 1, 3, 4	4, 3, 2, 1	3, 2, 4, 1
30	1, 3, 2, 4	2, 3, 1, 4	1, 4, 2, 3
31	2, 1, 4, 3	3, 1, 2, 4	4, 1, 3, 2
32	2, 3, 1, 4	1, 3, 4, 2	2, 4, 3, 1